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ANALYSES OF VALUE-ADDED FOR CASE-READY BEEF, WITH SPECIAL EMPHASIS ON TEXAS

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Analyses of Value-added for Case-ready Beef, with Special Emphasis on Texas

R.A. Dietrich, D.E. Farris, and J.B. Ward*

*Respectively, associate professor, professor, and research associate, Texas Agricultural Experiment Station, Department of Agricultural Economics, Texas A&M University, College Station, Texas.

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Executive Summary

Advancements in packaging technology for retail case-ready beef provide potential for decreasing the cost of merchandising beef at retail and increasing the value-added from beef at the packer/processor level. Adoption of case-ready packaging technology by the beef industry transfers the function of retail cutting and packaging of fresh beef from the retail store to the slaughter/processing plant. The economic impact emanating from case-ready beef has the potential to generate structural changes in the beef industry; revolutionize beef purchasing, handling, and merchandising practices; and affect beef's competitive position in the market place through cost reducing technologies.

Centralized beef fabrication and processing, which involved breaking carcasses into primals, sub-primals, and other cuts by major retailers in the 1960's at a central facility rather than in the backroom of a retail store, was the forerunner of the current boxed-beef system. During the 1970's, centralized cutting and packaging moved back toward the slaughter plants with the establishment of highly specialized beef slaughtering and boxed-beef fabrication facilities. The boxed-beef innovation took about 25 years from introduction to more than 80 percent adoption by the beef industry. In 1990, slaughter and processing plants added about $12 per hundredweight to the value of beef at wholesale as a result of boxed beef.

Case-ready beef has significant implications for production and slaughter regions since services formally added at the retail level are now added at the slaughter level, and of increased importance to the consumer/producer are the reductions in marketing system costs. Adoption of case-ready beef could reduce the cost of beef fabricating and marketing as much as 10 cents per pound. Further, research results show that case-ready beef would add another 19 cents per pound ($19/cwt) at the slaughter or processing plant level. The value added to Texas beef would have been $200 million or more if 80 percent of the beef had been merchandised as case-ready beef, given the 1990 level of fed-beef production and fed-beef prices.

To date, adoption of retail case-ready beef in the United States has been slow. However, there were several firms at the retail and wholesale level that were merchandising case-ready beef in 1990. Similar to boxed beef, case-ready systems apparently will require considerable time for the technology, economics, and marketing to create adequate incentives for general adoption. Adoption of vacuum packaging systems has occurred for portion-controlled steak and other meat items in the hotel, restaurant, and institutional (HRI) trade where package appearance is not an important consideration. Although adoption of case-ready beef has been slow, a number of industry leaders have stated that case-ready beef packaging systems will become an integral part of the future beef industry, provided that packaging and associated economic problems are solved.

This study developed a national beef processing and distribution model (VAL-ADD model) to facilitate an economic analysis of alternative beef fabrication/packaging/distribution systems in the United States during 1988-89. The model incorporated 1988-89 industry supply, demand, and cost conditions to estimate optimal economic packaging/distribution systems for distributing and merchandising beef from packer/processors to retailers among 30 regions within the contiguous 48 states. Further, the VAL-ADD model estimated the competitive positions of specified regions in Texas and other areas of the United States in merchandising case-ready beef to retailers.

Seven fabrication/packaging/distribution beef systems (boxed beef, tray-ready,overwrap, vacuum package, gas flush, frozen, and HRI) are incorporated in the VAL-ADD model to provide information and guidelines to packer/processors, wholesalers, and retailers relative to the economics of specified case-ready beef systems. These packaging/distribution systems were analyzed under 14 different industry scenarios, which encompassed potential changes in packaging technology and costs, in labor costs, in transportation costs, in beef consumption, and in costs associated with advertising and promotion. These scenarios facilitated basic analyses dealing with the economics of alternative systems and also the economic impact on alternative beef packaging/distribution systems.

Selected findings of this report, which are based on least cost analyses, are as follows:

Highlight Summary

- Central-vacuum-packaged beef (case-ready systems are defined on pages 9 and 10) has the potential, from a least-cost basis, to be the predominant packaging/distribution system in beef merchandising if the current beef appearance problem can be overcome, or if consumers can be convinced to accept vacuum-packaged beef that is at least comparable to store cut beef in freshness, quality, and sanitation.
- Tray-ready packaging/distribution systems do not have the appearance problem, but were at a small cost disadvantage compared with vacuum-packaged beef. However, if wage rates or basic beef costs were to increase substantially more than other costs, tray-ready would have a cost advantage over vacuum-packaged beef.

- Central overwrap was generally at a cost disadvantage compared with vacuum-packaged and tray-ready systems because of a shorter shelf-life, combined with the necessity for more frequent store deliveries.
- Boxed beef will likely continue to be an important packaging/distribution system for the foreseeable future. Boxed beef will be important in the initial adoptive phase of the case-ready beef systems in combination with various case-ready alternatives.
- Gas-flush and frozen packaging/distribution systems were generally not cost competitive with other alternative packaging/distribution systems analyzed in this study.

Alternative Packaging/Distribution Systems with Merchandising Costs

Impact of Initial Start-up Merchandising Costs

- Given initial start-up merchandising costs, 33 percent of the domestic beef was merchandised as boxed beef, 37 percent was merchandised as vacuum-packaged beef, and 30 percent was distributed as HRI beef.
- Almost 60 percent of the boxed beef was merchandised to out-of-state markets. The major interregional distributor was Kansas, followed by Colorado, Montana-Idaho-Wyoming, and the Texas-Oklahoma Panhandle.
- More than 70 percent of the vacuum-packaged beef was shipped to out-of-state markets. Regions with a competitive advantage in merchandising vacuum-packaged beef were the Texas-Oklahoma Panhandle, Nebraska, Minnesota-Wisconsin, Kansas, Colorado, and Illinois.
- More than 51 percent of the HRI beef demand was filled from intrastate sources. Major shippers of HRI on an interregional basis were Nebraska, the Texas-Oklahoma Panhandle, South Texas, West Texas, Arizona, and North Dakota-South Dakota.

Impact of Short-run Adjustments in Merchandising Costs

- Three packaging/distribution systems accounted for the non-HRI domestic beef merchandised in the United States. Vacuum-packaged beef accounted for 83 percent of the total, followed by boxed beef with 14 percent and tray-ready with 3 percent.
- Sixty-two percent of the vacuum-packaged beef was shipped on an interregional basis. Major out-of-state shippers were Kansas, Texas-Oklahoma Panhandle, Nebraska, Colorado, and Minnesota-Wisconsin.
- Out-of-state domestic shipments of boxed beef originated from Kansas and Iowa. The export demand for United States beef was satisfied by shipments of boxed beef from Montana-Idaho-Wyoming, Colorado, and Utah-Nevada.
- Over 50 percent of the HRI beef requirements were obtained from suppliers within their own respective regions. Regions shipping on an interregional basis were Nebraska, West Texas, South Texas, Texas-Oklahoma Panhandle, and North Dakota-South Dakota.

Impact of Intermediate- and Long-run Adjustments in Merchandising Costs

- More than 97 percent of the non-HRI domestic beef was shipped as vacuum-packaged beef under the scenarios incorporating intermediate- and long-run adjustments in merchandising costs. Tray-ready beef accounted for the remaining 3 percent.
- More than two-thirds of the vacuum-packaged beef was distributed on an interregional basis by surplus regions such as Kansas, the Texas-Oklahoma Panhandle, Colorado, Nebraska, and Iowa.
- All boxed-beef shipments were destined for the export market. Originating suppliers were Colorado, Utah-Nevada, Washington-Oregon, and Montana-Idaho-Wyoming. The shipping pattern suggests that these regions have a locational advantage for exporting beef to Pacific Rim countries.
- Costs were minimized when surplus beef producing regions, such as the Texas-Oklahoma Panhandle, Kansas, Colorado, and Iowa, shipped their surplus beef to other regions as vacuum-packaged beef rather than HRI beef.
- Regions shipping surplus beef as HRI beef included Nebraska, North Dakota-South Dakota, West Texas, and South Texas. These four regions had a common thread—lower reported packer labor costs compared with other surplus beef regions.

Impact of Increases in Regional Wage Rates and Transportation Costs

- Tray-ready packaging/distribution was the dominant case-ready system for all of the non-HRI domestic beef merchandised when regional packer wage rates were increased 50 percent or more over 1989 packer wage rates. These results suggest that if wage rates were to increase faster than other packaging/distribution costs, the long-run competitive advantage would tend to favor tray-ready over other packaging/distribution systems.

- Increases of 50 percent and 100 percent inregional transportation rates had no impact on longer run optimal packaging/distribution systems utilized. Changes in distribution patterns included: (1) increases in intraregional shipments of beef whenever intraregional supplies permitted, and (2) total packaging and distribution costs increased with increases in regional transportation cost.

Economic Considerations for Alternative Packaging/Distribution Systems

Comparison of Total Retail Beef Costs by Packaging/Distribution System

- A comparison of retail costs revealed that the lowest retail costs, generally, accrued to vacuum-packaged beef, followed by tray-ready, overwrap, frozen, and boxed beef.
- If full (long-run) adoption of case-ready beef were achieved, given 1988-89 industry, economic, and consumption conditions, the VAL-ADD model revealed that central-vacuum-packaged beef would have the following per hundredweight cost advantages over other alternative packaging/distribution systems (Table 35):
  (1) $1.00 over tray-ready,
  (2) $3.00 over central overwrap,
  (3) Almost $7.00 over central frozen,
  (4) Almost $9.00 over boxed beef (the predominant 1988 system),
  (5) Almost $12.00 over central gas,
  (6) More than $22.00 over central HRI.
- Given a 50 percent increase in the regional packer wage rates, with other costs unchanged, tray-ready beef exhibited a $1.14/hundredweight cost advantage over vacuum-packaged beef.

Competitive Position of Packaging/Distribution Systems for Additional Markets

- In addition to the packaging systems, which are specified by the VAL-ADD model by shipment routes, the VAL-ADD model also provides estimates of the next lowest cost systems, which would enter the solution if a combination of supply and demand warranted such shipments. These would be as follows:
- During the adoptive phases of case-ready systems, given 1988-89 industry supply and demand conditions, vacuum-packaged beef exhibited a competitive advantage in 23 out of 24 next potential shipment routes in addition to those to which shipments were specified.
- Given a 50 percent increase in regional packer wage rates, with other costs at 1988-89 industry levels, tray-ready-packaged beef showed a competitive advantage in five out of eight potential shipment routes followed by vacuum packaged beef with a least cost competitive potential in two out of eight markets.

Implications of Industry Technology Adoption Rate

Initial Start-up Adoption

- Cost advantage of vacuum-packaged versus boxed beef on a regional basis was dependent upon the level of retail wage rates.
- Regions with relatively lower retail wage rates minimized total costs by fabricating beef purchased as boxed beef. Conversely, regions with relatively higher retail wage rates minimized costs by merchandising vacuum-packaged beef.

Short-run Adoption

- Assuming decreases in promotional activities and labor costs of approximately $3.00/hundredweight from initial start-up costs, the VAL-ADD model revealed that four-fifths of the non-HRI domestic beef would be merchandised as vacuum-packaged beef since slaughter level wage rates were substantially lower than retail level wage rates.
- Almost all of the remaining non-HRI domestic beef was destined only to those regions with the lowest retail labor rates.

Intermediate and Long-run Adoption

- Although vacuum-packaged beef accounted for 97 percent of the non-HRI domestic beef merchandised under intermediate- and long-run cost scenarios, tray-ready-packaged beef was a close competitor.
- The VAL-ADD model revealed that total retail costs were generally $1.13/hundredweight higher for tray-ready-packaged beef compared to vacuum-packaged beef for the intermediate- and long-run models employed in the study.
- Supplemental analyzes generated through the VAL-ADD model suggested that cost changes accruing from such items as packaging technology advances, labor requirements, promotional activities, or basic product expenditures tend to provide a competitive advantage to one packaging/distribution system over another system depending upon the direction of cost changes. Cost increasing activities tended to provide a

competitive edge to tray-ready over vacuum-packaged beef. Similarly, cost decreasing activities provided a competitive edge to vacuum packaged beef over tray-ready beef.

Competitive Position of Texas Regions

- Texas-Oklahoma Panhandle slaughter/fabricating firms have a competitive advantage in shipping HRI-packaged beef to Southern California. The Texas-Oklahoma Panhandle enjoys a locational advantage for shipping vacuum-packaged beef to markets throughout the Southeast and Southern California.
- West Texas and South Texas, with their relatively low wage rates, are strong competitors for nearby HRI-packaged beef markets. West Texas has a locational advantage for the Southern California HRI market, while South Texas competes for the nearby Houston and Southeastern HRI markets.

Packaging Considerations for Industry

- Focus on reducing costs and offering partial or full line of case-ready products at a discount.
- Add frozen beef cuts or prepared entrees to frozen food sections of supermarkets or to the food section of general merchandise discount stores.
- The greatest opportunities for economies are for suppliers in the Southern and Central Plains to supply case-ready beef to retailers in areas with highest retail meat department wages.
- A variety of central packaging systems are available. Costs range about 10 cents per pound of packaged product with the vacuum package being the lowest and gas flush the highest.
- Tray-ready and central overwrap can compete on cost and appearance with the conventional store-cut product under some conditions.
- It will take time, experimentation, plus employee and customer education to find the best combination for each market.

Introduction

Technological developments in fresh beef packaging, health-safety considerations, and enhanced shelf-life have the potential to greatly alter the economics of beef distribution and beef merchandising through retail case-ready beef. The industry and economic impact emanating from case-ready beef has similar implications to that of the boxed-beef revolution in the 1960's. The advent of boxed beef, among other things, generated structural changes in the beef industry; it revolutionized beef purchasing, handling, and merchandising practices; and further increased the efficiency of beef marketing.

Fresh red meat has been one of the last food items to be prepared and packaged for the retail case inside the food store. Sales of case-ready fresh meat prepared and packaged outside of the retail store represented less than five percent of the total fresh meat sales in 1989.[1] Nevertheless, the majority of meat industry executives, including processors and distributors, believe that case-ready products will become a significant, if not dominant, part of fresh meat sales.[2] Vacuum-packaged, portion-controlled, fresh and frozen steaks and roasts for the hotel, restaurant, and institution (HRI) trade have been a standard method of distribution for several years. Studies conducted during the 1970's documented the feasibility of alternative fresh beef distribution systems.[3,4,5] Two studies conducted during the 1980's focused on potential cost savings associated with case-ready meat sales.[6,7]

Problem

Although technically feasible, the economic, marketing, and technology issues associated with case-ready beef distribution are complex. Some firms merchandising case-ready fresh beef experienced lower than anticipated sales due to such factors as purge, lack of acceptable fresh beef color, packaging, and merchandising costs. However, recent technological advances in packaging and distribution systems are showing promise in the United States, Europe, and Japan. A variety of central fabrication and beef packaging systems are currently being used on a small scale in the United States. Some of these systems offer longer shelf-life and reduced costs, other systems offer "fresh cut" appearance but at a higher cost. To date (1991), prepackaged, retail, case-ready, fresh beef has shown only limited success on an industry wide basis.

Beef, at the same time, has been losing market shares to pork, poultry, and fish due in part to higher prices at retail. The poultry industry, for example, was able to reduce fabrication and marketing costs by adopting a centrally-packaged, chill-pack system. The results have been increased efficiencies for poultry and increased retail shelf-life while providing higher quality products to the consumer. It appears that there are opportunities for the beef industry to reduce costs and/or add value to retail beef through changes in fabrication, packaging, and merchandising associated with case-ready beef.

Although continued technical improvements in current beef packaging materials are desirable, existing technology, materials, and methods are acceptable provided problems associated with costs, management, and merchandising are solved. To facilitate the orderly adoption of new technologies and management systems associated with retail case-ready systems, analyses of the economics of the alternative fabrication/distribution systems are required. Other prerequisites include analyses of the price premiums and/or discounts associated with each packaging system and minimal regional cost locations for various system activities.

Objectives

The objectives of this study are to: (1) determine the value added to case-ready beef by evaluating the economics of six alternative fabrication/packaging systems compared with the conventional system of fabricating and packaging retail beef in the backroom of the retail store and (2) analyze these alternative systems to determine potential competitive advantages by system for packers and/or purveyors expanding into retail, packaged-fresh and prepared beef.

Method of Analysis

Analytical Model

A national transshipment model for beef fabrication and marketing (VAL-ADD model) was developed to determine optimal economic systems and methods of packaging and distributing case-ready beef from packer/processors to retailers in different market areas. Further, the study was designed to estimate the competitive advantages of specified regions in Texas and other areas of the United States in supplying case-ready beef to retailers.

The general specifications of the VAL-ADD model are shown in Appendix A. The detailed specifications of the VAL-ADD model are available in Ward et al.[8] The model developed for this study is a multidimensional transshipment model in which the combined costs of fabricating, packaging, transporting, and merchandising case-ready fresh beef are minimized. More specifically, given such regional cost data as fabrication and packag-

ing, transportation, merchandising, and associated expenditures, the model allocates case-ready fresh beef so that total costs associated with fabricating, packaging, and distributing beef to consumers are minimized. These results provide an estimate of the delivered cost on a regional basis for specified packaging/distribution systems.

The contiguous 48 states were delineated into 30 regions to reflect regional differences in beef production, consumption, wage rates, and other economic considerations relative to beef fabrication/packaging systems (Figure 1). Twenty-two of these regions include one or more states, the remaining eight regions consist of regional delineations within the states of California, Texas, and Oklahoma. These three states were divided into multiple regions to reflect additional differences in beef fabrication, wage rates, and retail demand.

Fabrication/Packaging Systems and Models Employed

Fabrication/Packaging Systems

Seven fabrication/packaging beef systems are specified in this study to provide information and guidelines to packer/processors, wholesalers, and retailers relative to the economics of specific case-ready beef systems. The fabrication, packaging, and distribution systems designed for this study are as follows:

Conventional Boxed Beef: Packers and wholesalers under this system fabricate carcasses and ship wholesale primal and subprimal products (boxed beef) to stores for on-site fabrication into retail products that are packaged in foam trays with a film overwrap. The conventional system is designed to depict the most common (1988) packaging/ distribution system utilized by the beef industry. The conventional system will be used as a base for comparing other alternative systems specified below.

Tray-ready: Packers or wholesalers fabricate carcasses and subprimals that are pre-trimmed, pre-sliced, and then vacuum packaged for shipping to stores for on-site packaging in foam trays with a film overwrap.

Central Overwrap: Packers or wholesalers centrally fabricate carcasses and ship to stores retail products packaged in foam trays with a film overwrap, ready for the meat case. This system limits distribution to within a radius of 200 miles.

Central Vacuum: Packers or wholesalers centrally fabricate carcasses and ship to stores retail products vacuum packaged in an oxygen barrier film, ready for the meat case.

Central Gas: Packers or wholesalers centrally fabricate carcasses into case-ready retail produ

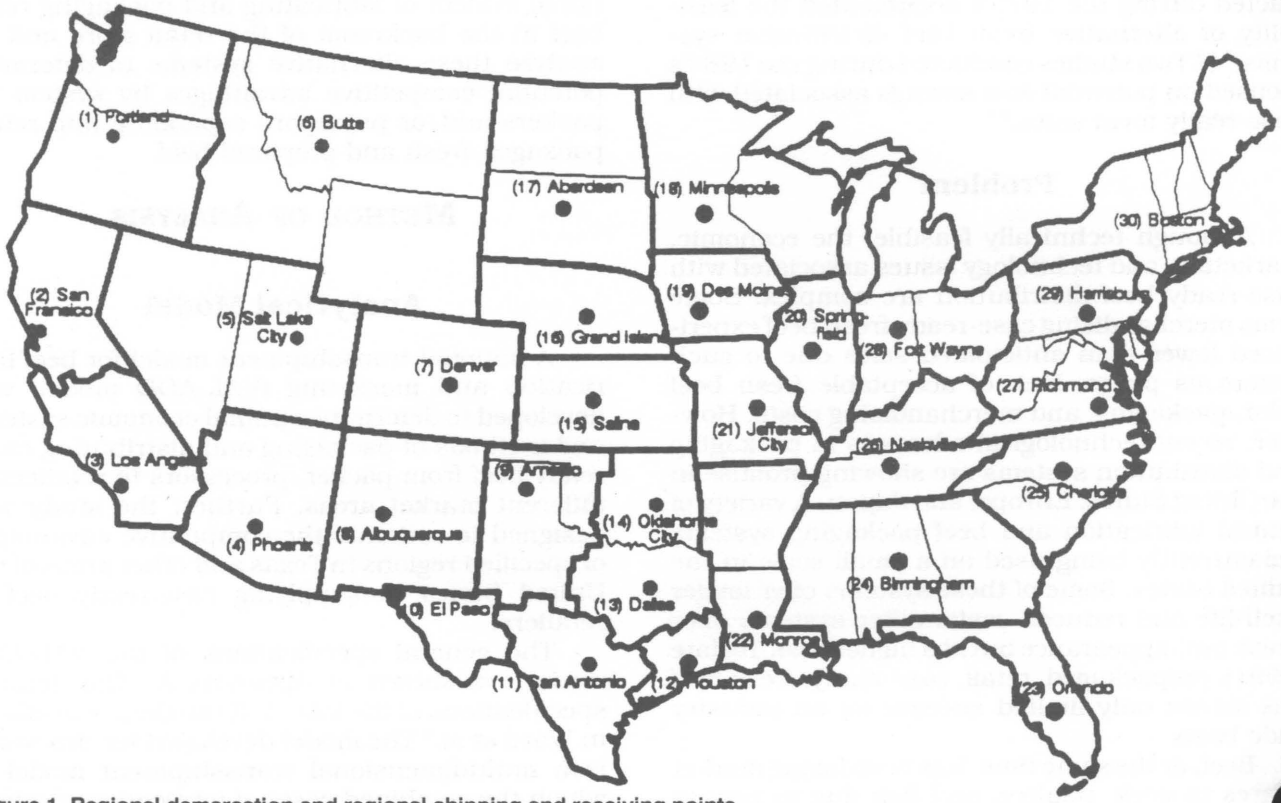

Figure 1. Regional demarcation and regional shipping and receiving points.

film overwrap, which are then packed in bulk gas flushed boxes with a barrier film for shipment to retail stores.

Central Frozen: Packers or wholesalers centrally fabricate carcasses and ship to stores retail products (vacuum packaged in an oxygen barrier film and frozen), ready for the meat case.

Central HRI: Packers or wholesalers centrally fabricate carcasses and ship to the hotel and restaurant industry retail products vacuum packaged in an oxygen barrier film, ready for storage.

Models Employed

Fourteen models were designed to provide insights and guidelines for decision making by packer/processors, wholesalers, and retailers relative to the economics of alternative beef packaging/distribution systems. These models were designed to represent the following industry scenarios.

Model 1 depicts the predominant beef distribution system (boxed beef) used by the industry during 1988. Model 1 provides a basis for establishing cost and associated distribution criteria for determining the economic efficiency of the alternative systems specified in this study compared with boxed beef. This model and all ensuing models require that 30 percent of the beef be shipped as HRI-packaged beef to the various demand regions to approximate industry shipment patterns during 1988.

Model 2 provides estimates of the least-cost packaging/distribution systems and associated shipment routes and opportunity costs when all seven packaging/distribution systems are considered. This model does not incorporate start-up merchandising costs. The results, therefore, are optimal only up to the retail case for the packaging/distribution systems and associated budgets developed for this study.

Models 3, 4, 5, and 6 incorporated all of the assumptions of Model 2. In addition, Model 3 analyzes the impact of initial start-up merchandising costs by packaging/distribution system. Model 4 analyzes the impact of short-run adjustments in merchandising costs on optimum packaging/distribution systems, while Model 5 incorporates interim time period adjustments in merchandising costs. In addition, Model 6 measures the impact of potential longer run adjustments in merchandising costs and fixed costs on optimal packaging/distribution systems. Retail wage costs for case-ready systems are reduced to 75 percent of the former models to reflect use of fewer skilled employees in the meat department. This applies to the remaining models.

Models 7 through 14 incorporate all of the assumptions of Model 6 and are designed to measure the impact of some regional and/or national changes in beef demand, beef supplies, wage rates, and transportation costs on optimal packaging/distribution systems. Model 7 is designed to measure the impact of regional shifts in beef demand, and Model 8 determines the impact of regional shifts in fed-beef supplies. Model 9 measures the combined impact of regional shifts in beef demand and beef supplies on optimum packaging/distribution systems. Model 10 measures the impact of a 50 percent increase in regional packer labor costs and Model 11 measures the combined impact of a 50 percent increase in regional packer and retail labor costs. Model 12 is designed to measure the impact of a 25 percent increase in Nebraska labor costs on packaging/distribution systems and competitive alignments. Models 13 and 14 reflect the economic impact of a 50 and 100 percent increase in transportation costs, respectively, on optimum packaging/distribution systems.

Data Requirements

The economics of beef packaging/distribution, including regional location of such activities, are impacted by such regional factors as labor costs, transportation costs, facility investment costs, carcass prices, surplus/deficit beef supplies, beef demand, packaging costs, merchandising costs, and other variable and annual fixed cost items. Packaging, labor, and transportation cost data for this study were obtained directly from various industry sources as packaging firms, packers, wholesalers/purveyors, retailers, and transportation firms. Other important sources were United States Departments of Agriculture, Labor, and Commerce and prior publications dealing with case-ready beef systems.[3,4,5]

Estimated regional carcass beef supplies, hourly wage rates, and beef consumption developed for this study are shown in Table 1. Regional carcass-beef supplies were obtained from U.S. Department of Agriculture. Regional hourly wage rates were obtained through a telephone survey of packer, wholesaler, and retail firms in each region. Beef consumption was estimated on a regional basis as shown in Appendix B. In addition to hourly wage rates, beef fabrication output per man-hour at the packer/wholesale and retail levels, by fabrication/packaging system, was necessary for estimating labor cost associated with each system, Table 2. Labor support personnel, as shown in Table 3, are also an important ingredient of the labor requirement for performing the fabrication/packaging activities at the packers/wholesalers and retailer levels. Both the fabrication output per man-hour and labor support requirements were derived from industry data and consultation with packer, wholesale, and retail firms producing case-ready beef. The total basic retailing costs associated with delivering the packaged beef product to the consumer, by packaging/distribution system, consists of packer/processor costs, including carcass cost, and costs associ-

Table 1. Estimated carcass-beef supplies, hourly wage costs, and beef consumption, by region, 1988.

Region	Carcass-beef[a] supply	Beef[a] consumption	Hourly wage costs[b]		
			Packers	Wholesalers	Retailers
	1,000 pounds	1,000 pounds	Dollars		
(1) WA-OR	616,079	538,937	12.38	13.31	16.07
(2) N. CA	556,965	810,199	11.05	19.33	20.25
(3) S. CA	383,706	1,571,596	11.45	15.26	16.69
(4) AZ	279,039	240,129	8.04	8.43	12.53
(5) UT-NV	293,929	185,581	11.49	11.05	13.29
(6) MT-ID-WY	499,865	148,768	10.63	11.67	10.94
(7) CO	1,489,370	252,768	10.20	10.69	13.03
(8) NM	77,501	92,778	7.84	7.43	13.33
(9) TX-OK PAN	2,418,142	124,125	9.75	8.50	11.62
(10) W. TX	634,283	60,965	8.74	8.75	12.51
(11) S. TX	502,625	266,939	7.60	9.11	10.63
(12) SE. TX	23,106	337,512	8.76	10.25	14.05
(13) E. TX	270,058	444,536	9.94	10.26	13.57
(14) E. OK	108,462	202,350	10.66	10.14	10.22
(15) KS	4,038,986	185,682	10.18	11.42	14.37
(16) NE	3,766,457	118,572	8.36	9.50	12.86
(17) ND-SD	468,134	95,745	8.64	9.24	12.59
(18) MN-WI	1,493,971	690,043	10.27	8.25	18.90
(19) IA	1,243,205	206,954	10.47	8.86	12.90
(20) IL	802,730	936,948	9.92	12.55	16.74
(21) MO	228,142	377,822	10.05	13.42	12.39
(22) AR-LA	38,739	423,514	8.61	8.66	9.86
(23) FL	105,134	896,290	6.87	6.62	12.87
(24) MS-AL-GA	370,727	803,604	9.52	7.37	10.54
(25) NC-SC	135,405	627,169	8.31	9.57	10.93
(26) KY-TN	204,608	556,733	9.56	9.64	14.82
(27) VA-W.VA MD-DE	60,025	932,575	6.59	9.03	17.25
(28) MI-IN-OH	571,063	1,857,756	10.76	10.07	13.71
(29) PA	672,612	897,738	10.02	9.97	11.10
(30) NE (7 states)	329,015	3,184,618	10.42	14.00	15.99

[a]Carcass beef supplies and beef consumption are for 1988. The methodology for developing estimates of beef supplies and consumption is reported in Ward et al., "Program and Model Documentation for Analysis of Value-Added for Beef--With Special Emphasis on Texas," Departmental Programming Model Documentation, PMD 91-1, TAES.

[b]Hourly wage costs include fringe benefits, are for 1989, and were obtained through a telephone survey of packer, wholesale, and retail firms in each region.

Table 2. Estimated volume of beef fabrication/processed per man-hour, by fabrication/packaging system, packer-wholesalers, and retailers, 1988.

Fabrication/ Packaging	Fabrication/Packaging System						
	Boxed Beef	Tray-Ready	Central Overwrap	Central Vacuum	Central Gas	Central Frozen	Central HRI
Packers/	Pounds/Man-Hour [a]						
Wholesalers	430	177	106	106	106	106	70[b]
Retailers	117	205	228	228	228	228	116[b]

[a]Represents Choice beef carcass proportions to facilitate comparison among systems.

[b]Assumes added labor for portion cutting is partially offset by large volume automated ground beef patty operations.

Table 3. Estimated support labor requirements, by fabrication/packaging system, packer-wholesalers, and retailers, 1988[a].

Fabrication/ Packaging	Fabrication/Packaging System						
	Boxed Beef	Tray-Ready	Central Overwrap	Central Vacuum	Central Gas	Central Frozen	Central HRI
Packers/	Pounds/Man-Hour						
Wholesalers	1667	667	400	400	400	400	400
Retailers	100	108	119	119	119	119	119

[a]Support labor is supplemental labor such as clean-up, maintenance, management, etc. necessary to perform the primary function of fabrication and packaging.

ated with performing the retailing function, ble 4. All cost items are shown in retail equivat values. These basic cost items undergo substantial change, by packaging/distribution system, as the VAL-ADD model considers economies of scale, changes in merchandising costs, and adoption rates, Table 32.

Given the carcass cost at the packer/wholesaler level, variations in costs between systems are associated with cost differences in fixed cost, labor, packaging, distribution, and "other", which includes utilities, supplies, variable interest, sales and advertising, and earnings before taxes as shown in Tables 5 and 6. For example, differences in packaging costs between systems reflect primarily packaging material costs and volume of beef per package, Table 4. Labor cost differences between systems are reflective of throughput or beef output per man-hour expended among systems and, in the case of HRI, also generally tighter specification requirements. The value-added to the boxed-beef system at the packer/wholesaler level as defined by the cost of services, labor, and materials was $11.55 per hundredweight (177.03 minus 165.48), Table 4. In comparison, the value of the services and materials added to the carcass in the central-overwrap system at the packer/wholesale level was $31.63. The value of total services and materials added to the central-overwrap system at retail was $49.55. The additional cost of services associated with the central-erwrap system as compared with boxed beef is primarily due to the fabrication and packaging costs being moved back to the processing plant from the retail store. In addition, the average meat department wage costs are generally higher than average beef packer or processor wage costs.

Labor costs and other costs are the major cost categories at the retail level (Tables 4 and 5). "Other" cost items, which are further detailed in Tables 5 and 6, vary considerably, depending upon beef fabrication/packaging system. Store shrink is a major cost item for fabrication/packaging systems for the other retail cost categories, Table 6. Labor, the single most important cost item at retail, ranged from 27 percent of the retailing cost for the central-overwrap and tray-ready system to 38 percent for the boxed-beef system, Table 4.

Analysis of the combined packer/wholesale and retail function cost items, *excluding carcass cost*, reveals that labor costs are the single most important non-carcass cost item ranging from 27 percent for central gas to 36 percent for the boxed-beef system, Table 4. The second most important cost item for the boxed-beef, tray-ready, and central overwrap systems was store shrink, which ranged from a low of 10 percent of the total non-carcass cost for the central vacuum systems to 23 percent for the boxed-beef system (Tables 4 and 6). The second most important cost item for the central vacuum, central-gas, and central-frozen systems was packaging cost, which ranged from a low of 12 percent of the non-carcass costs for the central-frozen system to 20 percent for the central gas.

Given the above basic cost data, regional transportation, and unloading costs for shipping beef as shown in Table 7, the transshipment model allocates fresh beef among regions to retailers

Table 4. Beef and packaging/distribution cost, by system and cost categories, packers, retailers, and total costs, short-run adoption (Model 3), 1988[a].

Item	System						
	Boxed Beef	Tray-Ready	Central Overwrap	Central Vacuum	Central Gas	Central Frozen	Central HRI
	dollars/cwt						
Packers:							
Carcass	165.48	165.48	165.48	165.48	165.48	165.48	165.48
Fixed	0.84	1.10	1.00	1.18	1.18	1.18	0.93
Labor	2.86	5.53	9.73	9.76	9.76	9.76	16.06
Package	2.24	2.60	5.21	10.10	18.43	10.10	10.10
Distribution	2.75	2.75	5.35	2.75	3.72	2.27	4.20
Other	2.86	10.03	10.34	10.34	11.34	16.04	11.78
Sub-Total	177.03	187.49	197.11	199.61	209.91	204.83	208.55
Retailers:							
Fixed	7.72	6.72	6.32	6.32	6.32	8.49	13.52
Labor	25.56	15.75	14.59	14.63	14.63	14.63	19.63
Package	5.20	5.20	0.00	0.00	0.00	0.00	0.00
Distribution	3.11	3.11	0.00	3.11	3.53	2.57	3.70
Other	24.89	26.39	28.64	19.99	21.04	19.99	11.29
Sub-Total	66.48	57.17	49.55	44.05	45.52	45.68	48.14
Total Cost:							
Carcass	165.48	165.48	165.48	165.48	165.48	165.48	165.48
Fixed	8.56	7.82	7.32	7.50	7.50	9.67	14.45
Labor	28.42	21.28	24.32	24.39	24.39	24.39	35.69
Package	7.44	7.80	5.21	10.10	18.43	10.10	10.10
Distribution	5.86	5.86	5.35	5.86	7.25	4.84	7.90
Other	27.75	36.42	38.98	30.33	32.38	36.03	23.07
Total System[a]	243.51	244.66	246.66	243.66	255.43	250.51	256.69

Source: Estimated from information provided by trade sources and other sources.

[a]Assumes short-run merchandising and other costs of $9/cwt for the case-ready systems. Long-run costs are shown in Table 32. Higher 1990 carcass costs would increase these total costs by about $15/cwt.

Table 5. Other operating costs, by system, packers, 1988[a].

em	Boxed Beef	Tray-Ready	Central Overwrap	Central Vacuum	Central Gas	Central Frozen	Central HRI
	dollars/cwt						
Utilities	0.78	1.28	1.53	1.53	2.53	3.53	1.78
Supplies	0.34	0.40	0.46	0.46	0.46	0.46	0.50
Variable Interest	0.11	0.15	0.15	0.15	0.15	0.15	0.25
Sales & Advertising[b]	0.48	1.85	1.85	1.85	1.85	3.70	5.55
Earnings Before Taxes[c]	1.15	1.85	1.85	1.85	1.85	3.70	3.70
Total Other Costs	$2.86	$5.53	$5.84	$5.84	$6.84	$11.54	$11.78

Source: Estimated from personal interviews with beef fabricators and from industry financial reports in Meat Facts, AMI.

[a] Assumes an average sales price of $165/cwt for boxed beef (AMI Meat Facts, 1989).

[b] Tray-Ready, Central OVerwrap, Central Vacuum, and Central Gas=1%, Central Frozen=2%, and Central HRI=3% of the wholesale boxed beef price in retail terms ($185/cwt).

[c] Boxed Beef=0.7% of $165/cwt. Tray-Ready, Central Overwrap, Central Vacuum, Central Gas, and Central Frozen=1%, and Central HRI=2% of the wholesale boxed beef price in retail terms, $185/cwt.

Table 6. Other operating costs, by system,retailers, 1988[a].

	Boxed Beef	Tray-Ready	Central Overwrap	Central Vacuum	Central Gas	Central Frozen	Central HRI
	dollars/cwt						
Store "Shrink"[b]	17.80	15.30	17.80	7.60	10.20	7.60	5.10
Supplies	1.00	0.50	0.25	0.25	0.25	0.25	0.10
Sales & Advertising[c]	1.00	1.00	1.00	2.55	1.00	2.55	1.00
Income & Other[d]	5.09	5.09	5.09	5.09	5.09	5.09	5.09
Total Other Costs	$24.89	$21.89	$24.14	$15.49	$16.54	$15.49	$11.29

[a] Assumes a retail value of $255/cwt.

[b] 7% store cut "shrink", 2% on vacuum packcage (Bishop, 8%, 3%).

[c] 1% of sales for central vacuum and central frozen.

[d] 2% of average retail beef price ($255/cwt).

Table 7. Total beef distribution rates, in dollars per hundredweight, by region, 1988-89[a].

Originating Region/Area	Destination Region																												
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)	(13)	(14)	(15)	(16)	(17)	(18)	(19)	(20)	(21)	(22)	(23)	(24)	(25)	(26)	(27)	(28)	(29)	(30)
(1) WA-OR	1.44	5.94	6.52	6.53	5.80	5.48	6.49	6.73	7.48	7.07	8.05	8.19	7.91	7.72	7.63	7.25	6.81	6.56	6.65	6.98	6.84	7.16	7.66	7.19	9.74	6.98	9.80	6.89	9.67	9.95
(2) N.CA	5.93	1.45	5.29	5.78	5.71	6.18	6.47	6.27	7.04	6.39	7.53	7.79	7.55	7.42	7.47	7.25	7.34	6.86	6.69	6.99	6.86	6.93	7.44	6.97	9.68	6.88	9.85	6.94	9.71	10.12
(3) S.CA	6.54	5.32	1.42	4.97	5.67	6.31	6.32	5.75	6.54	5.75	6.98	7.26	7.05	6.94	6.99	7.21	7.36	6.85	6.62	6.84	6.57	6.56	7.15	6.66	9.23	6.56	9.54	6.83	9.45	9.95
(4) AZ	7.00	6.18	5.26	1.32	5.59	6.29	5.79	5.06	5.89	4.97	6.35	6.67	6.44	6.33	6.45	6.76	7.16	6.50	6.24	6.35	6.14	6.08	6.72	6.28	8.77	6.20	9.06	6.46	9.05	9.55
(5) UT-NV	6.20	6.11	6.03	5.59	1.32	5.01	5.20	5.40	6.23	5.90	6.92	7.13	6.83	6.57	6.42	6.06	6.32	6.00	5.78	6.16	6.00	6.36	6.98	6.45	8.76	6.31	8.97	6.18	8.72	9.19
(6) MT-ID-WY	5.89	6.68	6.80	6.34	5.06	1.27	5.77	6.13	6.77	6.55	7.50	7.63	7.30	7.03	6.90	6.50	5.83	5.76	5.91	6.32	6.24	6.73	7.09	6.61	8.96	6.50	8.95	6.24	8.76	9.22
(7) CO	7.02	7.00	6.80	5.84	5.25	5.77	1.27	5.02	5.23	5.53	6.30	6.46	6.02	5.67	5.44	5.18	5.81	5.45	5.17	5.43	5.29	5.77	6.51	5.87	8.01	5.71	8.24	5.73	8.10	8.64
(8) NM	7.28	6.78	6.18	5.11	5.45	6.13	5.02	1.27	4.87	4.64	5.88	6.14	5.76	5.52	5.68	6.10	6.56	5.97	5.71	5.79	5.57	5.57	6.32	5.81	8.11	5.78	8.43	5.98	8.48	8.94
(9) TX-OK PAN.	7.67	7.23	6.69	5.66	5.97	6.42	5.00	4.67	1.36	5.01	5.44	5.67	5.09	4.79	5.07	5.49	6.56	5.64	5.35	5.47	5.21	5.12	6.01	5.45	7.65	5.43	7.99	5.73	7.96	8.57
(10) W.TX	7.63	6.89	6.15	5.00	5.93	6.53	5.51	4.62	5.22	1.29	5.57	5.97	5.71	5.80	5.93	6.51	6.88	6.13	5.88	6.05	5.75	5.54	6.33	5.83	8.14	5.87	8.51	6.17	8.53	9.16
(11) S.TX	8.26	7.74	7.14	6.09	6.62	7.10	5.99	5.60	5.44	5.33	1.36	4.61	4.85	5.36	5.71	6.29	7.08	5.98	5.64	5.76	5.45	4.84	5.75	5.28	7.43	5.40	7.98	5.83	8.18	8.76
(12) SE.TX	8.37	7.97	7.40	6.36	6.77	7.20	6.11	5.82	5.64	5.68	4.58	1.39	4.75	5.32	5.70	6.36	7.04	5.95	5.59	5.55	5.34	4.53	5.47	5.00	7.23	5.20	7.61	5.69	7.80	8.44
(13) E.TX	8.09	7.73	7.19	6.15	6.51	6.89	5.71	5.47	5.07	5.44	4.83	4.76	1.38	4.63	5.14	5.93	6.67	5.62	5.21	5.32	4.98	4.41	5.59	4.98	7.07	5.04	7.58	5.54	7.71	8.36
(14) E.OK	7.92	7.62	7.10	6.07	6.29	6.67	5.41	5.27	4.79	5.55	5.36	5.35	4.65	1.36	4.48	5.47	6.32	5.40	4.98	5.11	4.71	4.79	5.75	5.10	7.19	5.04	7.60	5.37	7.48	8.23
(15) KA	7.83	7.67	7.15	6.18	6.15	6.55	5.20	5.41	5.07	5.66	5.71	5.73	5.16	4.48	1.36	5.06	6.01	5.14	4.66	4.88	4.54	5.10	5.93	5.23	7.31	5.04	7.55	5.19	7.56	8.14
(16) NE	7.44	7.45	7.38	6.46	5.82	6.18	4.96	5.80	5.49	6.20	6.29	6.39	5.95	5.47	5.06	1.36	5.47	4.77	4.40	4.99	4.78	5.63	6.16	5.51	7.51	5.29	7.64	5.18	7.44	8.05
(17) ND-SD	6.98	7.54	7.53	6.83	6.06	5.55	5.54	6.23	6.56	6.55	7.08	7.07	6.69	6.32	6.01	5.47	1.36	4.73	5.16	5.55	5.56	6.24	6.59	6.07	8.18	5.84	8.08	5.53	7.85	8.37
(18) MN-WI	7.65	8.03	7.99	7.05	6.49	6.18	5.82	6.40	6.35	6.60	6.76	6.76	6.34	6.06	5.74	5.29	5.24	1.17	4.32	4.83	4.87	6.28	6.15	5.56	7.30	5.27	7.35	4.87	7.10	7.69
(19) IA	7.78	7.84	7.72	6.77	6.26	6.36	5.52	6.12	6.00	6.33	6.36	6.33	5.87	5.56	5.18	4.86	5.78	4.33	1.16	4.42	4.37	5.48	5.95	5.27	7.13	4.94	7.18	4.70	6.95	7.59
(20) IL	8.17	8.20	7.98	6.88	6.67	6.79	5.80	6.21	6.14	6.51	6.49	6.27	5.99	5.71	5.43	5.56	6.23	4.83	4.41	1.17	4.18	4.98	5.66	4.88	6.46	4.42	6.60	4.28	6.62	7.25
(21) MO	8.01	8.05	7.66	6.66	6.50	6.71	5.65	5.97	5.84	6.19	6.14	6.02	5.58	5.24	5.03	5.32	6.27	4.88	4.37	4.19	1.16	5.15	5.60	4.82	6.66	4.56	6.93	4.69	6.78	7.56
(22) AR-LA	8.43	8.15	7.65	6.60	6.92	7.28	6.20	5.98	5.74	5.96	5.40	5.06	4.90	5.35	5.72	6.36	7.10	6.30	5.49	5.00	5.16	1.15	5.20	4.46	6.96	4.59	7.12	5.20	7.43	8.08
(23) FL	9.42	9.13	8.73	7.60	7.91	7.98	7.30	7.07	7.06	7.10	6.74	6.41	6.56	6.74	6.97	7.27	7.81	6.38	6.17	5.86	5.79	5.36	1.10	4.77	5.85	5.32	6.48	5.61	6.87	7.68
(24) MS-AL-GA	8.81	8.53	8.09	7.08	7.28	7.42	6.55	6.48	6.36	6.52	6.14	5.82	5.78	5.92	6.09	6.43	7.16	5.77	5.45	5.05	4.98	4.59	4.78	1.10	5.64	4.06	6.35	4.92	6.59	7.37
(25) NC-SC	9.05	9.01	8.58	7.59	7.58	7.69	6.92	7.00	6.98	7.04	6.79	6.64	6.50	6.58	6.69	6.86	7.45	5.91	5.78	5.30	5.44	5.65	4.70	4.55	1.54	4.56	5.27	4.96	6.40	6.64
(26) KY-TN	8.53	8.42	7.97	6.99	7.11	7.29	6.35	6.44	6.34	6.56	6.30	6.08	5.86	5.84	5.84	6.16	6.86	5.46	5.10	4.57	4.71	4.72	5.33	4.06	5.66	1.10	6.19	4.54	6.49	7.24
(27) VA-WVA-MD-DL	9.10	9.15	8.85	7.82	7.74	7.68	7.10	7.25	7.28	7.34	7.27	6.97	6.93	6.93	6.89	6.97	7.35	5.94	5.80	5.39	5.62	5.76	5.13	5.03	5.26	4.92	1.55	4.93	5.04	6.01
(28) MI-IN-OH	8.38	8.45	8.28	7.26	6.93	6.94	6.34	6.64	6.68	6.88	7.39	6.66	6.46	6.23	6.00	5.98	6.43	5.01	4.81	4.39	4.81	5.33	5.59	4.89	6.19	4.51	6.16	1.13	5.94	6.69
(29) PA	9.00	9.04	8.78	7.82	7.55	7.54	7.00	7.31	7.26	7.36	7.45	7.15	7.06	6.84	6.91	6.80	7.16	5.76	4.83	5.41	5.52	5.99	5.40	5.21	6.39	5.13	5.05	4.78	1.54	5.62
(30) North East	9.23	9.39	9.20	8.20	7.91	7.88	7.41	7.66	7.77	7.86	7.94	7.69	7.60	7.47	7.39	7.31	7.59	6.17	6.09	5.85	6.07	6.44	5.94	5.72	6.61	5.63	5.99	5.28	5.59	1.57

[a]Total distribution rate includes transportation, warehousing, loading, and unloading costs.

such that total costs associated with fabrication/packaging and distribution are minimized given the alternative systems previously specified. This produces estimates of cost comparisons of alternative systems by region. Some packaging/distribution systems, such as central overwrap, often result in shipments of 200 miles or less for local distribution. Beef short-haul distribution rates, including transportation rates, warehousing, and unloading costs as shown in Table 8, were developed to accommodate short-haul distribution patterns. These are included in the total distribution rates in Table 7. For example, on an interregional shipment from a packer/processor in the Texas-Oklahoma Panhandle to Southern California, the total distribution cost is $6.69/cwt. This includes the local distribution cost of $3.42/cwt from a warehouse in Southern California to individual retail stores (Table 8). Intraregional shipments normally do not include warehousing, therefore, shipments not exceeding 200 miles did not include a warehousing cost.

Table 8. Beef short haul transportation rates, warehousing costs, and unloading costs, by region, 1988.

Region		Short haul transportation rates[a]	Warehouse costs	Unloading costs	Total short haul distribution costs
		Dollars/cwt.			
(1)	WA-OR	1.26	2.00	0.18	3.44
(2)	N. CA	1.26	2.00	0.19	3.45
(3)	S. CA	1.26	2.00	0.16	3.42
(4)	AZ	1.14	2.00	0.13	3.27
(5)	UT-NV	1.14	2.00	0.16	3.30
(6)	MT-ID-WY	1.14	2.00	0.13	3.27
(7)	CO	1.14	2.00	0.13	3.27
(8)	NM	1.14	2.00	0.13	3.27
(9)	TX-OK PAN	1.23	2.00	0.13	3.36
(10)	W. TX	1.14	2.00	0.15	3.29
(11)	S. TX	1.23	2.00	0.13	3.36
(12)	SE. TX	1.23	2.00	0.16	3.39
(13)	E. TX	1.23	2.00	0.15	3.38
(14)	E. OK	1.23	2.00	0.13	3.36
(15)	KS	1.23	2.00	0.13	3.36
(16)	NE	1.23	2.00	0.13	3.36
(17)	ND-SD	1.23	2.00	0.13	3.36
(18)	MN-WI	1.02	2.00	0.15	3.17
(19)	IA	1.02	2.00	0.14	3.16
(20)	IL	1.02	2.00	0.15	3.17
(21)	MO	1.02	2.00	0.14	3.16
(22)	AR-LA	1.02	2.00	0.14	3.15
(23)	FL	0.96	2.00	0.14	3.10
(24)	MS-AL-GA	0.97	2.00	0.13	3.10
(25)	NC-SC	1.40	2.00	0.14	3.54
(26)	KY-TN	0.97	2.00	0.13	3.10
(27)	VA-W. VA-MD-DE	1.40	2.00	0.15	3.55
(28)	MI-IN-OH	0.97	2.00	0.16	3.13
(29)	PA	1.39	2.00	0.15	3.54
(30)	NE (7 states)	1.39	2.00	0.18	3.57

ource: Estimated from data from a national survey. Details are in Ward, J. B., and D. E. Farris, "Estimating Truck Rates for Refrigerated Food Products". *Journal of Food Distribution Research*, Vol 21:2, pp. 21-30, 1990.

[a]Short haul transportation rates depict routes within 200 miles of the local distribution center.

packaged in foam trays with an oxygen permeable In addition to the basic analyses dealing with the economics of alternative systems, this study also is concerned with the economic impact upon alternative beef fabrication/packaging systems resulting from potential changes in packaging technology and costs, labor costs, transportation costs, beef consumption, costs associated with advertising and promotion, and price premiums and/or discounts. The VAL-ADD model also is designed to facilitate shipments of surplus beef into the export market on a boxed beef basis.

Analysis of Beef Fabrication/ Packaging Systems

Factors impacting the optimal location and optimal beef fabrication/packaging system, given regional beef production and consumer demand, include: (1) the "system" costs as specified in Tables 4, 5, and 6; (2) regional labor and distribution costs, and (3) regional carcass price. Many of the costs remain constant over all regions by system, but labor rates, distribution costs, and carcass prices vary by region over all systems in this study.

The conventional beef fabrication/packaging system (boxed beef) for 1988 was used as a base for determining economic efficiencies associated with previously specified alternative beef fabrication/packaging systems. The VAL-ADD model designed for this study facilitates analysis of the competitive relationship between the various beef fabrication packaging systems. A further requirement for all systems and/or scenarios in this study is that 30 percent of all domestic beef consumption must be obtained from hotel, restaurant, and institution (HRI) sources to coincide with current U.S. consumption patterns.

Conventional Boxed-beef Packaging/ Distribution System

Packers and wholesalers, under the boxed-beef system, fabricate carcasses for shipment as wholesale primal and subprimal products to retail stores for on-site fabrication into retail products and packaging in foam trays with a film overwrap. The conventional system, represented by Model 1, depicts the most common packaging/distribution system for beef during 1988 and provides a base for comparing cost and associated distribution criteria for determining the economic efficiency of the various alternative systems specified in this study.

Model 1 reveals that the total cost of merchandising, packaging, and distributing 18.071 billion pounds of fresh beef to consumers in the contiguous 48 states and 494 million pounds to export markets would have been $2.49 per pound if boxed beef had been the predominant packaging/distribution system utilized, Table 9. Since this study required that 30 percent of all fresh beef distributed in the contiguous 48 states be fabricated and distributed as HRI packaged beef for the HRI industries in all models employed, the 18.071 billion pounds of fresh beef (retail equivalent weight) would be merchandised in the contiguous 48 states as follows if costs were minimized: (1) 70 percent as boxed beef for further fabrication and packaging into retail cuts at retail stores, and (2) 30 percent to the HRI industries. The remaining 494 million pounds (retail equivalent) is exported to foreign markets as boxed beef in this model and all ensuing models employed.

Table 10 and Figure 2 show that boxed beef distribution costs are minimized when 42 percent of the boxed beef is shipped on an intraregional basis, 55 percent is shipped on an interregional basis, and 3 percent moved into export. Regions competing for out-of-state markets for boxed beef included Kansas, Texas-Oklahoma Panhandle, Colorado, Iowa, and Minnesota-Wisconsin.

Least-cost results from the VAL-ADD model show that the Texas-Oklahoma Panhandle could compete for boxed beef markets in the Southeastern states, East and Southeast Texas, the Southwestern states, and Southern California, Figure 2. Major markets for Kansas were the Atlantic Coast states, the Northeast, and Michigan-Indiana-Ohio. Kansas shared the Northeast boxed-beef market with Iowa and Minnesota-Wisconsin. Colorado was a major supplier to the West Coast boxed-beef markets where it competed with the Texas-Oklahoma Panhandle for the Southern California market. Export markets were satisfied by Washington-Oregon, Montana-Idaho-Wyoming, Utah-Nevada, and Colorado. While it is likely that some of the larger packers in the Plains states exported beef to foreign markets during 1988-89, these results show that Northwestern plants have a slight locational shipping cost advantage to Far Eastern

Table 9. Model 1- Optimum shipments of boxed beef and HRI packaged beef, 1988[a].

Packaging/distribution system	Beef shipped (million pounds)
Boxed beef:	
Domestic market	12,648
Export market	494
HRI	5,423
Total shipped	18,565

[a] Model 1 was designed to determine the optimum shipment routes and opportunity costs for the predominant packaging/distribution system (boxed beef) used by the industry during 1988. Model 1 and all ensuing models require that 30 percent of the beef be shipped as HRI packaged beef to approximate industry shipment patterns during 1988.

Table 10. Model 1 - Optimum shipments of boxed beef and opportunity shipping costs, by region, 1988.

Originating Region/Area	Destination Region* (1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)	(13)	(14)	(15)	(16)	(17)	(18)	(19)	(20)	(21)	(22)	(23)	(24)	(25)	(26)	(27)	(28)	(29)	(30)	(31)	Total Shipped
(1) WA-OR	377	1.72	2.50	3.53	5.94																										135	512
(2) N.CA	7.24	393	4.03	5.55	8.61																										2.97	393
(3) S.CA	7.68	3.70	262	4.57	8.40																										3.63	262
(4) AZ	7.22	3.64	2.91	130	7.40																										4.75	130
(5) UT-NV	3.30	0.44	0.56	1.15	130																										63	193
(6) MT-ID-WY	2.78	0.80	1.11	1.68	3.54	104	5.62	2.47	6.41	4.38	3.96	2.96	3.21	3.35	6.34	5.38	5.34	4.93	4.99	3.14	2.50	2.62	2.10	2.17	2.44	2.26	2.20	1.84	2.05	1.87	261	365
(7) CO	2.78	175	710	0.06	2.60	3.38	177	0.24	3.75	2.24	1.64	0.67	0.81	0.87	3.76	2.95	4.20	3.49	3.12	1.13	0.43	0.54	0.39	0.31	0.38	0.34	0.37	0.21	0.27	0.17	35	1097
(8) NM	6.56	3.30	2.89	2.85	6.31	7.26	7.27	38	6.91	4.87	4.74	3.87	4.06	4.23	7.51	7.38	8.47	7.53	7.18	5.01	4.23	3.85	3.71	3.77	3.98	3.93	4.07	3.98	4.16	3.98	4.82	38
(9) TX-OK PAN.	3.55	0.35	128	38	3.44	4.15	3.84	27	87	1.84	0.90	236	162	0.11	3.50	3.37	5.07	3.80	3.42	1.28	0.46	296	627	301	0.12	0.18	0.23	0.32	0.25	0.21	2.19	1902
(10) W.TX	5.40	1.89	1.35	1.22	5.28	6.14	6.23	1.83	5.74	43	2.91	2.18	2.49	3.00	6.24	6.27	7.27	6.17	5.83	3.75	2.89	2.30	2.21	2.27	2.50	2.50	2.64	2.64	2.70	2.69	2.69	43
(11) S.TX	7.32	4.04	3.64	3.60	7.27	8.01	8.01	4.11	7.26	5.34	187	2.12	2.94	3.85	7.32	7.35	8.77	7.32	6.89	4.75	3.89	2.90	2.93	3.01	3.09	3.33	3.40	3.61	3.65	3.58	4.00	187
(12) SE.TX	9.48	6.31	5.94	5.92	9.46	10.15	10.18	6.37	9.51	7.73	5.27	0.94	4.88	5.85	9.35	9.47	10.77	9.34	8.89	6.59	5.82	4.64	4.69	4.78	4.93	5.18	5.08	5.51	5.31	5.31	5.46	
(13) E.TX	7.69	4.56	4.21	4.20	7.69	8.34	8.27	4.52	7.43	5.99	4.01	2.80	149	3.66	7.28	7.52	8.89	7.49	7.00	4.85	3.95	3.00	3.31	3.25	3.27	3.51	3.53	3.85	3.71	3.71	4.13	149
(14) E.OK	7.13	4.06	3.74	3.73	7.08	7.72	7.57	3.92	6.76	5.70	4.15	3.00	2.88	87	6.23	6.68	8.15	6.89	6.38	4.25	3.29	3.00	3.07	2.96	2.99	3.12	3.16	3.29	3.09	3.20	3.78	87
(15) KA	3.92	1.00	0.67	0.73	3.83	4.49	4.25	0.96	3.92	2.70	1.38	0.26	0.27	54	130	3.15	4.73	3.51	2.95	0.91	56	0.19	0.14	188	439	281	653	739	0.06	692	2.26	3232
(16) NE	4.08	1.32	1.45	1.56	4.04	4.66	4.56	1.90	4.89	3.79	2.51	1.48	1.61	1.55	4.25	83	4.74	3.69	3.23	1.56	0.80	1.28	0.92	0.82	0.75	0.80	0.64	0.54	0.49	0.45	3.41	83
(17) ND-SD	2.99	0.78	0.97	1.30	3.65	3.41	4.51	1.69	5.33	3.51	2.68	1.52	1.73	1.76	4.57	3.47	67	3.02	3.36	1.49	0.95	1.26	0.72	0.76	0.79	0.72	0.45	0.25	0.26	0.14	0.58	67
(18) MN-WI	4.20	1.81	1.96	2.06	4.62	4.57	5.33	2.40	5.66	4.10	2.89	1.75	1.92	2.05	4.84	3.84	4.42	483	3.06	1.31	0.80	1.83	0.81	0.78	0.45	0.69	0.26	0.14	0.05	572	1.09	1055
(19) IA	4.43	1.72	1.80	1.87	4.49	4.85	5.13	2.22	5.41	3.93	2.59	1.42	1.54	1.64	4.38	3.51	5.06	3.26	145	1.00	0.39	1.13	0.72	0.59	0.38	0.46	0.18	0.06	85	710	1.48	940
(20) IL	7.07	4.33	4.31	4.23	7.15	7.54	7.66	4.55	7.80	6.36	4.97	3.61	3.91	4.04	6.88	6.46	7.76	6.01	5.50	656	2.45	2.88	2.67	2.45	1.95	2.19	1.85	1.89	1.92	1.91	3.33	656
(21) MO	7.48	4.75	4.56	4.59	7.55	8.03	8.09	4.89	8.06	6.61	5.19	3.94	4.07	4.14	7.04	6.78	8.36	6.63	6.03	3.59	208	3.62	3.18	2.97	2.73	2.90	2.76	2.87	2.65	2.79	4.30	208
(22) AR-LA	10.42	7.37	7.07	7.04	10.49	11.11	11.15	7.41	10.49	8.90	6.97	5.49	5.91	6.77	10.25	10.35	11.72	10.56	9.67	6.92	6.52	2.14	5.30	5.12	5.55	5.45	5.47	5.90	5.82	5.83	6.70	
(23) FL																							4.85								9.99	
(24) MS-AL-GA																							3.12	74	2.46	3.16	2.94	3.86	3.22	3.36	4.26	74
(25) NC-SC																							7.52	7.92	2.84	8.13	6.33	8.37	7.50	7.11	7.71	
(26) KY-TN																							3.48	2.77	2.28	108	2.57	3.28	2.92	3.03	4.46	108
(27) VA-WVA-MD-DE																							10.88	11.34	9.49	11.42	5.54	11.28	9.08	9.41	10.98	
(28) MI-IN-OH																							3.86	3.72	2.94	3.54	2.68	562	2.50	2.62	4.08	562
(29) PA																							5.57	5.93	5.04	6.06	3.46	5.55	544	3.43	4.37	544
(30) North East																														255	0.00	255
Total	377	568	1100	168	130	104	177	65	87	43	187	236	311	141	130	83	67	483	145	656	264	296	627	563	439	389	653	1301	629	2229	494	13142

*Underscored figures are shipments (in million pounds). Other figures are opportunity costs (in dollars per hundredweight) which result from not having an activity in the optimum solution.

Figure 2. Optimal distribution of boxed beef (Model 1).

Regional beef shipment patterns in Model 1 generally coincide with that experienced by the beef industry during 1988 and with prior studies [9,10]. Specific regional shipment patterns in ensuing models, although similar to Model 1, may vary because of differences in regional fabrication/packaging system costs. Costs were minimized when almost one-third of the HRI-packaged beef was supplied by intrastate sources, Table 11 and Figure 3. Because of a favorable estimated wage rate, Nebraska supplied about three-fourths of the beef shipped on an interregional basis under the scenario posited by Model 1. Nebraska had a competitive advantage in supplying HRI beef to the major markets in the Midwest, the Northeast, the Atlantic Coast, and Southeast states. South Texas shipped HRI beef to East and Southeast Texas. West Texas competed with Arizona for the Southern California HRI market, while it had a competitive disadvantage in the San Francisco market of only $0.95 per hundredweight. North Dakota-South Dakota competed with Nebraska for the Northern California HRI markets and also supplied all of the HRI beef requirements for Washington-Oregon markets.

The five surplus HRI-beef regions have a common thread—these regions reported slightly lower labor costs for fabricating HRI beef than did other regions. The model employed in this study is highly sensitive and likely allocated more of the surplus beef in Nebraska for shipment as HRI beef than normally occurs because of relatively low reported wage rates. Nevertheless, these results strongly suggest that regions and/or processors with lower labor cost, other things equal, have a competitive advantage in marketing HRI beef.

Data in Tables 10 and 11 provide not only the volume of beef shipped/merchandised between surplus and deficit regions (underlined figures), but also "opportunity costs" (non underlined figures). Given the basic regional data relative to beef supplies and demand, carcass costs, and associated costs related to packaging/distribution systems, the VAL-ADD model allocates beef among regions, by packaging/distribution system, such that total costs are minimized. The opportunity costs in Table 10 for the Texas-Oklahoma Panhandle (9) show that the next best boxed beef markets for the Texas-Oklahoma Panhandle are Eastern Oklahoma (14) and North Carolina-South Carolina (25) with opportunity costs of $0.11 and $0.12 per hundredweight, respectively. An opportunity cost of $0.11 per hundredweight suggests that if some cost component associated with either price, packaging, transportation costs, etc., were to decline by at least $0.11 per hundredweight, the Texas-Oklahoma Panhandle would have a competitive advantage in shipping beef to Eastern Oklahoma, provided supply/demand conditions warranted such shipments. An examination of the

Table 11. Model 1 - Optimum shipments of HRI beef and opportunity shipping costs, by region, 1988.

Originating Region/Area	Destination Region* (1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)	(13)	(14)	(15)	(16)	(17)	(18)	(19)	(20)	(21)	(22)	(23)	(24)	(25)	(26)	(27)	(28)	(29)	(30)	Total Shipped
(1) WA-OR	1.14	6.13	7.17	12.14	8.70																										
(2) N.CA	7.58	0.95	5.96	11.66	9.20																										
(3) S.CA	8.97	6.31	1.54	10.91	9.59																										
(4) AZ	3.29	1.24	24	72	3.11																										96
(5) UT-NV	4.48	3.51	3.55	7.86	56																										56
(6) MT-ID-WY	2.42	2.77	3.10	7.37	3.11	45	7.63	8.42	9.63	9.10	10.93	7.20	6.34	6.26	8.94	10.69	9.83	6.87	6.70	5.91	6.10	5.56	5.31	5.77	6.09	5.74	5.89	5.50	5.89	5.67	45
(7) CO	2.30	1.44	1.30	4.82	1.57	4.00	76	4.95	5.52	5.76	7.32	3.64	2.62	2.40	4.94	6.91	7.99	4.58	3.77	2.77	2.87	2.31	2.63	2.88	2.87	2.74	3.02	2.93	3.09	3.00	76
(8) NM	2.44	0.86	0.10	3.47	1.62	4.29	4.44	28	4.72	4.17	6.44	2.90	1.96	1.92	5.03	8.02	8.86	5.11	4.32	3.06	3.04	1.75	2.09	2.51	2.75	2.59	3.04	3.05	3.40	3.19	28
(9) TX-OK PAN.	2.64	1.14	0.48	3.91	2.01	4.34	4.02	3.77	37	4.33	5.39	1.81	0.57	0.45	3.73	6.72	8.47	4.23	3.39	2.19	2.10	0.69	1.23	1.57	1.67	1.68	1.99	2.28	2.24	2.24	37
(10) W.TX	2.90	0.95	448	3.24	2.27	4.81	5.10	4.01	5.17	18	5.90	2.58	1.81	2.28	5.34	8.57	9.27	5.28	4.51	3.37	3.24	1.63	2.03	2.46	2.72	2.65	3.10	3.26	3.40	3.46	466
(11) S.TX	3.30	1.69	0.95	4.33	2.77	5.13	5.28	4.95	4.98	4.61	80	81	61	1.08	4.47	7.70	9.04	4.53	3.61	2.40	2.26	0.06	0.63	1.10	1.13	1.42	1.76	2.23	2.35	2.32	222
(12) SE.TX	7.38	5.95	5.24	8.65	6.91	9.19	9.38	9.19	9.19	9.04	7.80	21	3.76	4.92	8.37	11.73	12.88	8.39	7.45	6.00	5.99	3.50	4.11	4.59	4.73	5.04	5.12	5.91	5.69	5.75	21
(13) E.TX	7.33	5.96	5.30	8.71	6.89	9.11	9.16	9.04	8.70	9.05	8.55	4.51	73	4.27	7.90	11.44	12.70	8.27	7.26	6.04	5.83	3.69	4.68	4.93	4.87	5.16	5.44	6.07	5.92	5.99	73
(14) E.OK	7.84	6.55	5.93	9.35	7.31	9.52	9.45	9.49	9.04	9.97	10.10	6.14	4.74	1.05	7.67	11.52	12.93	8.70	7.66	6.47	6.18	5.02	5.66	5.87	5.81	5.92	6.23	6.57	6.34	6.56	
(15) KS	3.77	2.71	2.07	5.59	3.18	5.42	5.21	5.79	5.53	6.22	6.69	2.79	1.57	0.87	56	6.96	8.55	4.37	3.27	2.20	2.00	1.56	2.02	2.15	2.06	1.99	2.24	2.38	2.53	2.50	56
(16) NE	0.82	111	0.06	3.65	0.32	2.50	2.49	4.01	3.80	4.66	5.20	1.43	0.39	61	2.26	36	5.37	1.46	0.51	231	113	76	165	0.20	61	126	207	557	269	955	2968
(17) ND-SD	162	132	0.15	4.07	0.54	1.43	3.22	4.51	5.27	5.04	6.26	2.30	1.37	1.13	3.55	5.09	29	1.25	1.51	0.70	1.03	0.77	0.51	0.91	0.87	0.69	0.52	0.38	0.47	0.34	323
(18) MN-WI	4.15	3.89	3.99	7.54	4.34	5.51	6.80	7.92	8.10	8.28	8.93	4.98	4.00	3.90	6.29	7.98	8.04	207	3.40	2.78	3.15	3.98	2.99	3.28	2.70	2.98	2.59	2.55	2.49	2.47	207
(19) IA	4.77	4.02	4.00	7.53	4.41	6.20	6.76	7.91	8.00	8.29	8.73	4.75	3.70	3.56	5.87	7.74	9.27	4.23	62	2.58	2.81	3.19	3.11	3.26	2.86	2.91	2.74	2.70	2.68	2.74	62
(20) IL	6.72	5.93	5.75	9.07	6.39	8.23	8.55	9.42	9.58	9.93	10.30	6.04	5.26	5.16	7.61	10.17	11.32	6.35	5.33	50	3.90	3.82	4.04	4.06	3.22	3.51	3.24	3.45	3.56	3.60	50
(21) MO	7.25	6.48	6.05	9.52	6.92	8.88	9.11	9.83	9.90	10.22	10.55	6.45	5.42	5.23	7.78	10.58	12.14	7.21	6.03	4.37	1.07	4.85	4.73	4.75	4.30	4.49	4.52	4.84	4.58	4.84	
(22) AR-LA	8.10	6.85	6.26	9.64	7.76	9.95	10.15	10.06	9.97	10.09	9.66	5.21	4.61	5.60	9.03	12.36	13.61	9.54	7.93	5.81	6.35	51	4.35	4.41	4.97	4.74	5.02	5.81	5.76	5.83	51
(23) FL																							104								104
(24) MS-AL-GA																							3.41	241	2.67	3.65	3.56	5.09	4.20	4.47	241
(25) NC-SC																							5.84	6.78	127	6.94	4.48	7.69	6.45	5.92	127
(26) KY-TN																							4.10	3.38	2.57	41	3.18	4.38	3.91	4.13	41
(27) VA-WVA-MD-DE																							6.66	7.70	4.84	7.66	73	7.84	4.61	5.16	73
(28) MI-IN-OH																							6.55	6.68	5.42	6.24	5.20	2.24	5.15	5.38	
(29) PA																							6.96	7.86	6.44	7.88	4.23	7.51	0.18	4.47	
(30) North East																														0.63	
Total	162	243	472	72	56	45	76	28	37	18	80	102	134	61	56	36	29	207	62	281	113	127	269	241	188	167	280	557	269	955	5423

*Underscored figures are shipments (in million pounds). Other figures are opportunity costs (in dollars per hundredweight) which result from not having an activity in the optimum solution.

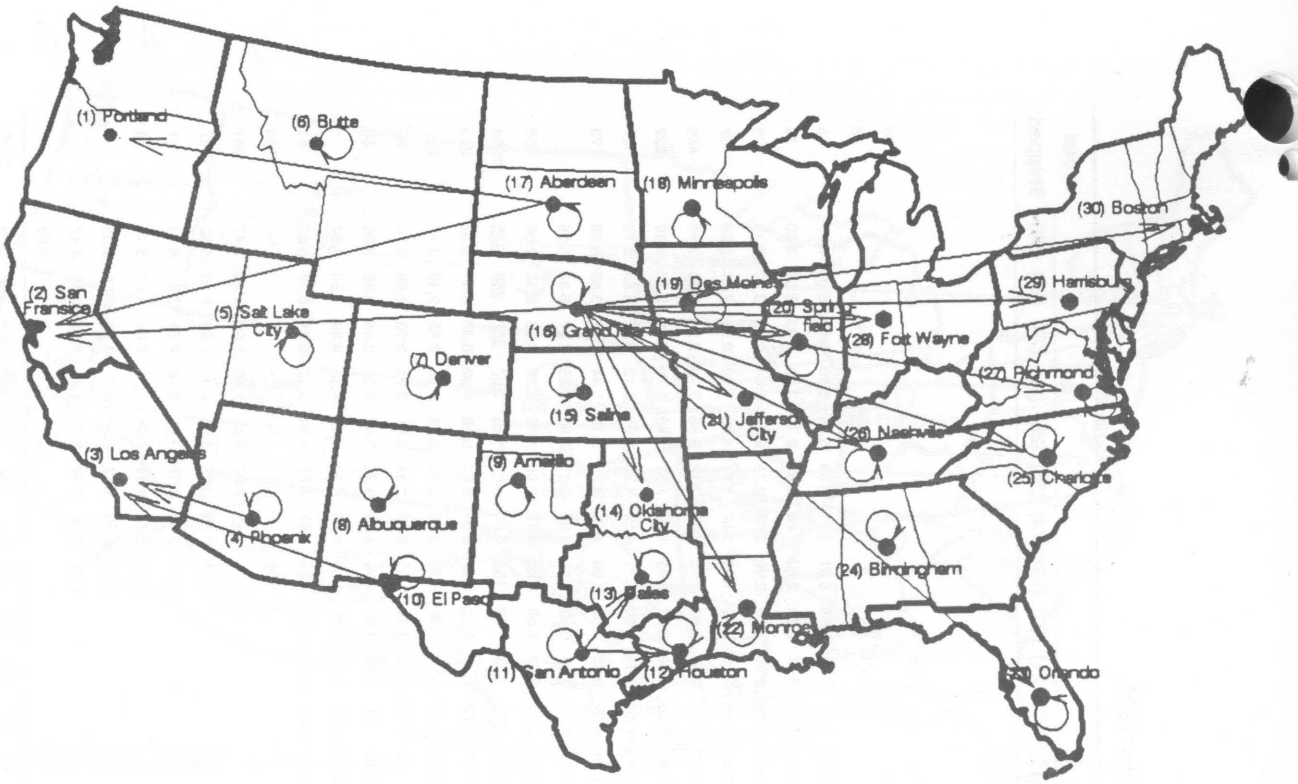

Figure 3. Optimal distribution of HRI beef (Model 1).

destination region opportunity costs in Table 10 reveals that if Kansas could not supply the beef requirements to Region 25 (North Carolina-South Carolina), the Texas-Oklahoma Panhandle would be the next best supplier for Region 25 with an opportunity cost of $0.12 per hundredweight for that market. A more detailed analysis of opportunity costs, by model, region, and packaging/distribution system is provided in a latter section of this report.

Alternative Beef Packaging/ Distribution Systems Without Start-up Merchandising Costs

Model 2 is designed to analyze simultaneously not only the boxed beef packaging/distribution system but also the tray-ready, the central-overwrap, the central-vacuum, the central-gas-flush, the central-frozen, and the HRI packaging/distribution systems to determine which system or combination of systems minimize total costs of distributing fresh beef to consumers. This model does not consider start-up merchandising costs. The results, therefore, are optimal only up to the retail case prior to merchandising.

Total costs are minimized when all of the non-HRI domestic beef is packaged and distributed to U.S. markets as central-vacuum-packaged beef, Table 12. Recall that 30 percent of the domestically consumed beef must be shipped as HRI beef in all models and that 2.7 percent of the total beef enters the export market as boxed beef in all models.

A word of caution in interpreting results from multi-product transshipment models. These models are highly sensitive and occasionally overstate changes in shipment patterns and packaging/distribution systems employed. Nevertheless, these models and the results provided are valuable tools for determining directions of potential changes in an industry. For example, multi-product transshipment models employed by Dietrich and based on 1969 data projected that the Texas-Oklahoma Panhandle, Kansas, Nebraska, and Colorado had the potential to account for 60.2 and 58.1 percent

Table 12. Model 2 - Optimum shipments of beef, without start-up merchandising costs, by packaging/distribution system, 1988.

Packaging/distribution system	Beef shipped (million pounds)
Boxed beef:	
Domestic market	0
Export market	494
Central vacuum	12,649
HRI	5,422
Total shipped	18,565

of the total cattle fed and slaughtered, respectively, in the U.S. in 1972.[10] During 1988 these regions accounted for 62.8 and 58.1 percent, respectively, of the cattle fed and slaughtered in the U.S.

Central Vacuum. Kansas and the Texas-Oklahoma Panhandle supplied 60 percent of the beef shipped on an interregional basis in Model 2, Figure 4 and Table 13. Kansas enjoyed a competitive advantage in shipping vacuum-packaged beef to the Atlantic Coast states and competed for the deficit Northeast market with Nebraska, Iowa, North Dakota-South Dakota, and Minnesota-Wisconsin. The Texas-Oklahoma Panhandle region had a competitive advantage in the Texas markets, the Southwestern states, Arkansas-Louisiana, and Florida. Colorado supplied all of the out-of-state vacuum-packaged beef to the Northern California market and most of the shipments to the Southern California region, where it competed with Texas-Oklahoma Panhandle suppliers. Export demand (boxed-beef shipments) was filled by Montana-Idaho-Wyoming, Washington-Oregon, Utah-Nevada, and Colorado.

Major beef suppliers such as Colorado, Texas-Oklahoma Panhandle, Kansas, Nebraska, Iowa, and North Dakota-South Dakota are very competitive for central-vacuum markets as indicated by the opportunity costs in destination Regions 20 through 30 for these suppliers, Table 13. Opportunity costs (which indicate decreases in delivered costs or increases in product prices necessary to enter a market) for these suppliers ranged from $0.01 to $0.99 per hundredweight in Regions 20 through 30.

HRI. Almost one-half of each region's HRI-beef demand was filled from sources within their own regions, Figure 5 and Table 14. Nebraska was the predominant supplier of HRI beef shipped on an interregional basis to deficit markets in the Northeast, the Atlantic Coast, and Southeastern states. South Texas shipped its surplus HRI beef to East Texas and to Arkansas-Louisiana in competition with Nebraska. West Texas shipped its surplus HRI beef west to Southern California. Washington-Oregon found it least costly to retain that portion of its beef production for its vacuum-packaged beef demand and then: (1) ship its remaining beef to the export market, and (2) import its HRI requirements from North Dakota-South Dakota.

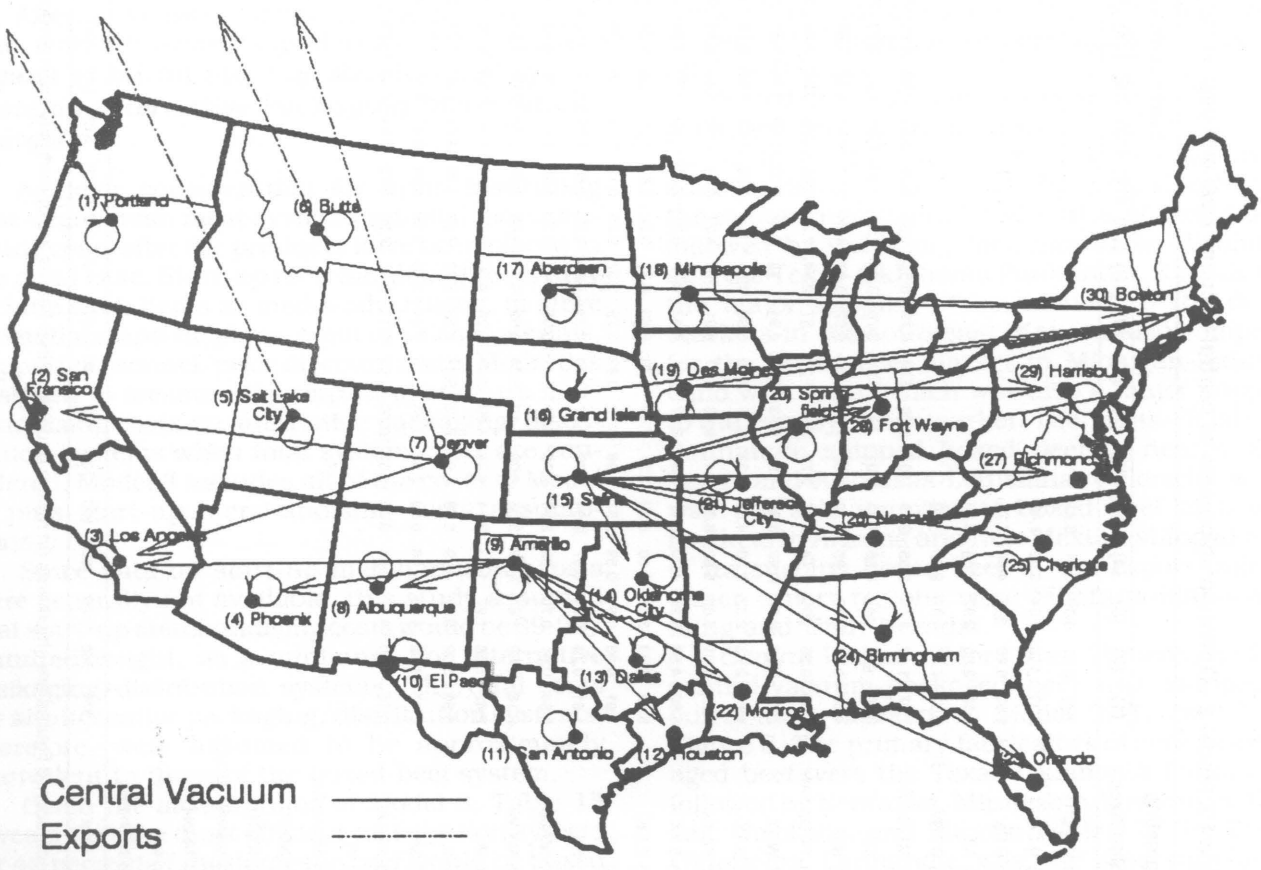

Figure 4. Optimal distribution of vacuum packaged and boxed beef exports without start-up merchandising costs (Model 2).

Table 13. Model 2 - Optimum shipments of central vacuum beef and opportunity shipping costs,without start-up merchandising costs, by region, 1988.

Originating	Destination Region*																													Total
Region/Area	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)	(13)	(14)	(15)	(16)	(17)	(18)	(19)	(20)	(21)	(22)	(23)	(24)	(25)	(26)	(27)	(28)	(29)	(30)	Shipped
(1) WA-OR	377	3.61	4.39	5.41	6.71																										377
(2) N.CA	5.36	150	4.04	5.55	7.49																										150
(3) S.CA	5.80	3.70	238	4.57	7.28																										238
(4) AZ	5.35	3.65	2.92	154	6.29																										154
(5) UT-NV	2.53	1.55	1.67	2.26	130																										130
(6) MT-ID-WY	1.27	1.17	1.49	2.05	2.79	104	5.99	2.84	6.79	5.55	5.64	3.34	3.58	3.86	6.85	6.34	5.99	5.44	5.50	2.75	3.00	2.99	2.46	2.68	2.94	2.77	2.70	2.35	2.56	2.37	104
(7) CO	0.90	418	467	0.06	1.48	3.01	177	0.24	3.76	3.04	2.95	0.68	0.81	1.01	3.89	3.54	4.48	3.63	3.26	0.37	0.56	0.54	0.39	0.45	0.51	0.48	0.50	0.35	0.40	0.30	1062
(8) NM	4.69	3.30	2.89	2.85	5.20	6.89	7.27	38	6.92	5.67	6.04	3.87	4.07	4.37	7.65	7.97	8.74	7.67	7.32	4.25	4.36	3.85	3.71	3.91	4.12	4.07	4.20	4.12	4.30	4.12	38
(9) TX-OK PAN.	1.68	0.35	395	14	2.32	3.78	3.85	27	87	2.64	2.21	236	223	0.25	3.64	3.96	5.35	3.94	3.56	0.53	0.60	296	624	0.14	0.26	0.32	0.36	0.46	0.38	0.35	1902
(10) W.TX	2.72	1.09	0.55	0.42	3.36	4.96	5.43	1.03	4.94	43	3.42	1.39	1.69	2.34	5.58	6.06	6.74	5.51	5.17	2.19	2.22	1.50	1.40	1.60	1.83	1.84	1.97	1.98	2.03	2.03	43
(11) S.TX	4.14	2.73	2.33	2.30	4.84	6.33	6.71	2.80	5.96	4.84	187	0.82	1.63	2.69	6.15	6.63	7.74	6.16	5.72	2.69	2.72	1.60	1.61	1.84	1.92	2.17	2.22	2.45	2.47	2.42	187
(12) SE.TX	7.29	6.01	5.63	5.62	8.04	9.47	9.88	6.07	9.21	8.23	6.27	0.64	4.58	5.69	9.19	9.75	10.74	9.18	8.72	5.53	5.64	4.33	4.38	4.61	4.76	5.02	4.90	5.34	5.14	5.14	
(13) E.TX	5.80	4.56	4.21	4.20	6.57	7.96	8.27	4.51	7.42	6.78	5.31	2.80	89	3.79	7.42	8.10	9.16	7.63	7.13	4.09	4.07	3.00	3.29	3.38	3.39	3.64	3.66	3.99	3.84	3.84	89
(14) E.OK	5.12	3.93	3.61	3.60	5.83	7.21	7.44	3.78	6.63	6.37	5.32	2.87	2.75	26	6.24	7.13	8.29	6.90	6.38	3.36	3.29	2.87	2.93	2.96	2.99	3.13	3.16	3.30	3.09	3.20	26
(15) KS	1.91	0.86	0.54	0.59	2.57	3.96	4.12	0.82	3.78	3.37	2.55	0.13	0.14	115	130	3.61	4.87	3.51	2.95	0.01	56	0.05	3	489	439	390	653	739	0.05	219	3233
(16) NE	1.61	0.73	0.86	0.97	2.34	3.70	3.97	1.30	4.31	4.00	3.22	0.89	1.02	1.10	3.80	83	4.42	3.24	2.78	0.22	0.34	0.68	0.33	0.37	0.29	0.35	0.18	0.09	0.03	866	949
(17) ND-SD	0.84	0.51	0.70	1.02	2.26	2.76	4.23	1.41	5.06	4.03	3.70	1.25	1.45	1.62	4.43	3.79	67	2.88	3.22	0.46	0.80	0.98	0.43	0.62	0.64	0.59	0.30	0.12	0.12	132	199
(18) MN-WI	2.18	1.68	1.84	1.92	3.36	4.06	5.19	2.26	5.52	4.76	4.06	1.62	1.78	2.05	4.84	4.29	4.55	483	3.06	0.42	0.79	1.69	0.67	0.78	0.44	0.69	0.25	0.14	0.04	572	1055
(19) IA	2.42	1.58	1.67	1.73	3.24	4.34	4.99	2.08	5.28	4.59	3.75	1.29	1.40	1.64	4.38	3.96	5.20	3.26	145	0.11	0.38	0.99	0.57	0.59	0.37	0.46	0.18	0.06	354	440	939
(20) IL	5.95	5.09	5.07	4.99	6.79	7.92	8.42	5.31	8.56	7.92	7.03	4.37	4.67	4.94	7.77	7.80	8.79	6.91	6.39	656	3.34	3.64	3.42	3.35	2.84	3.09	2.74	2.79	2.81	2.80	656
(21) MO	5.47	4.62	4.43	4.46	6.30	7.52	7.96	4.76	7.94	7.28	6.36	3.81	3.94	4.15	7.05	7.24	8.51	6.64	6.03	2.70	208	3.49	3.04	2.97	2.73	2.91	2.76	2.88	2.66	2.79	208
(22) AR-LA	8.16	7.00	6.70	6.67	9.00	10.37	10.78	7.04	10.12	9.32	7.90	5.12	5.54	6.53	10.02	10.56	11.62	10.33	9.43	5.79	6.28	1.76	4.92	4.88	5.31	5.21	5.23	5.66	5.58	5.59	
(23) FL																							2.97								
(24) MS-AL-GA																							2.99	74	2.46	3.17	2.94	3.87	3.23	3.37	74
(25) NC-SC																							6.88	7.43	2.33	7.64	5.83	7.88	7.00	6.61	
(26) KY-TN																							3.92	3.35	2.86	0.58	3.15	3.87	3.50	3.61	
(27) VA-WVA-MD-DE																							8.75	9.36	7.51	9.45	3.55	9.30	7.10	7.42	
(28) MI-IN-OH																							3.72	3.72	2.94	3.55	2.67	562	2.50	2.62	562
(29) PA																							5.44	5.94	5.05	6.07	3.46	5.56	274	3.45	274
(30) North East																														0.73	
Total	377	568	1100	168	130	104	177	65	87	43	187	236	312	141	130	83	67	483	145	656	264	296	627	563	439	390	653	1301	628	2229	12649

*Underscored figures are shipments (in million pounds). Other figures are opportunity costs (in dollars per hundredweight) which result from not having an activity in the optimum solution.

Figure 5. Optimal distribution of HRI beef without start-up merchandising costs (Model 2).

Alternative Beef Packaging/Distribution Systems with Adjustments in Merchandising Costs

Impact of Initial Start-up Merchandising Costs on Alternative Packaging/Distribution Systems

A major consideration for firms instituting case-ready fresh meat systems is initial merchandising costs after the products have been placed in the retail case. Start-up merchandising costs may include such items as media advertising, in store promotions and displays, point of sales materials, support personnel, price discounts, etc. Model 3 is designed to measure the impact of start-up merchandising costs on alternative packaging/distribution systems when total system costs are considered. Model 3 includes all of the costs of Model 2, plus start-up merchandising costs assumptions.

Since data on start-up merchandising costs were generally not available, this study assumed that start-up merchandising costs would be $9.00/hundred weight, as a minimum, for alternative packaging/distribution systems. The total costs for all alternative packaging/distribution systems, therefore, were assumed to be approximately equivalent to those of the boxed-beef system.

Given the assumptions of Model 3, Table 15 reveals that the most efficient distribution system for 40 percent of the domestic beef would be boxed beef and 37 percent would be packaged and distributed as central-vacuum beef. The remaining 30 percent of the domestic beef, again, was distributed as HRI beef.

Boxed Beef. Almost 60 percent of the beef packaged and distributed as boxed beef for the domestic market was merchandised to out-of-state markets, Table 16 and Figure 6. Kansas was the major interregional distributor of boxed beef, followed by Colorado, Montana-Idaho-Wyoming, and the Texas-Oklahoma Panhandle. Kansas was the major supplier of boxed beef to the deficit markets in the southeast. Kansas also competed for the boxed beef market in Michigan-Indiana-Ohio with Iowa, which was also a major supplier to the Pennsylvania market. The Texas-Oklahoma Panhandle shipped boxed beef to nearby East Texas and Arkansas-Louisiana. Colorado, which was the sole supplier of boxed beef to nearby markets in Arizona and New Mexico, shipped most of its surplus boxed beef to the export market. Other export regions were Montana-Idaho-Wyoming and Utah-Nevada.

Central Vacuum. More than 70 percent of the central-vacuum-packaged beef was shipped to out-of-state markets in Model 3, Table 17 and Figure 6. The primary fabricators of central-packaged beef were the Texas-Oklahoma Panhandle, followed by Nebraska, Minnesota-Wisconsin, Kansas, Colorado, and Illinois, Table 17. The Texas-Oklahoma Panhandle was the sole supplier of central-vacuum-packaged beef to Southern Cali-

Table 14. Model 2 - Optimum shipments of HRI beef and opportunity shipping costs, without start-up merchandising costs, by region, 1988.

Originating Region/Area	Destination Region* (1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)	(13)	(14)	(15)	(16)	(17)	(18)	(19)	(20)	(21)	(22)	(23)	(24)	(25)	(26)	(27)	(28)	(29)	(30)	Total Shipped
(1) WA-OR	0.07	5.91	6.71	10.28	8.70																										
(2) N.CA	5.78	243	4.77	9.07	8.47																										243
(3) S.CA	6.82	5.01	24	7.97	8.51																										24
(4) AZ	4.08	2.88	1.40	72	4.97																										72
(5) UT-NV	3.41	3.29	3.09	6.00	56																										56
(6) MT-ID-WY	1.35	2.55	2.64	5.51	3.11	45	7.63	6.38	9.24	8.64	9.99	6.26	6.12	5.74	9.06	9.69	8.76	7.07	7.07	4.91	5.10	4.56	4.31	5.31	5.09	4.74	4.89	4.50	5.68	4.67	45
(7) CO	1.23	1.22	0.84	2.96	1.57	4.00	76	2.91	5.13	5.30	6.38	2.70	2.40	1.88	5.06	5.91	6.92	4.78	4.14	1.77	1.87	1.31	1.63	2.40	1.87	1.74	2.02	1.93	2.88	2.00	76
(8) NM	3.41	2.68	1.68	3.65	3.66	6.33	6.48	28	6.37	5.75	7.54	4.00	3.78	3.44	7.19	9.06	9.83	7.35	6.73	4.10	4.08	2.79	3.13	4.09	3.79	3.63	4.08	4.09	5.23	4.23	28
(9) TX-OK PAN.	1.96	1.31	0.41	2.44	2.40	4.73	4.41	2.12	37	4.26	4.84	1.26	0.74	0.32	4.24	6.11	7.79	4.82	4.15	1.58	1.49	0.08	0.62	1.50	1.06	1.07	1.38	1.67	2.42	1.63	37
(10) W.TX	2.29	1.19	448	1.84	2.73	5.27	5.56	2.43	5.24	18	5.42	2.10	2.05	2.22	5.92	8.03	8.66	5.94	5.34	2.83	2.70	1.09	1.49	2.46	2.18	2.11	2.56	2.72	3.65	2.92	466
(11) S.TX	3.17	2.41	1.43	3.41	3.71	6.07	6.22	3.85	5.53	5.09	80	81	0.72	1.50	5.53	7.64	8.91	5.67	4.92	2.34	2.20	61	0.57	1.58	1.07	1.36	1.70	2.17	3.08	2.26	222
(12) SE.TX	7.25	6.67	5.72	7.73	7.85	10.13	10.32	8.09	9.74	9.52	7.80	21	4.48	5.34	9.43	11.67	12.75	9.53	8.76	5.94	5.93	3.44	4.05	5.07	4.67	4.95	5.06	5.85	6.42	5.69	21
(13) E.TX	6.48	5.96	5.06	7.07	7.11	9.33	9.38	7.22	8.53	8.81	7.83	3.79	133	3.97	8.24	10.66	11.85	8.69	7.85	5.26	5.05	2.91	3.90	4.69	4.09	4.38	4.66	5.29	5.93	5.21	133
(14) E.OK	6.24	5.80	4.94	6.96	6.78	8.99	8.92	6.92	8.12	8.98	8.63	4.67	3.99	61	7.26	9.99	11.33	8.37	7.50	4.94	4.65	3.49	4.13	4.88	4.28	4.39	4.70	5.04	5.60	5.03	61
(15) KS	2.58	2.37	1.49	3.61	3.06	5.30	5.09	3.63	5.02	5.64	5.63	1.73	1.23	0.23	56	5.86	7.36	4.45	3.52	1.08	0.88	0.44	0.90	1.57	0.94	0.87	1.12	1.26	2.20	1.38	56
(16) NE	0.75	0.78	0.60	2.79	1.32	3.50	3.49	2.97	4.41	5.20	5.26	1.49	1.17	0.48	3.38	36	5.30	2.66	1.88	231	113	15	165	0.74	61	18	207	557	0.79	700	2103
(17) ND-SD	162	0.85	0.76	3.28	1.61	2.50	4.29	3.54	5.95	5.65	6.39	2.43	2.22	1.68	4.74	6.16	29	2.52	2.95	0.77	1.10	0.84	0.58	1.52	0.94	0.76	0.59	0.45	1.33	0.41	191
(18) MN-WI	2.88	3.47	3.33	5.48	4.14	5.31	6.60	5.68	7.51	7.62	7.79	3.84	3.58	3.18	6.21	6.78	6.77	207	3.57	1.58	1.95	2.78	1.79	2.62	1.50	1.78	1.39	1.35	2.08	1.27	207
(19) IA	3.33	3.43	3.17	5.30	4.04	5.83	6.39	5.50	7.24	7.46	7.42	3.44	3.11	2.67	5.62	6.37	7.83	4.06	62	1.21	1.44	1.82	1.74	2.43	1.49	1.54	1.37	1.33	2.10	1.37	62
(20) IL	6.65	6.71	6.29	8.21	7.39	9.23	9.55	8.38	10.19	10.47	10.36	6.10	6.04	5.64	8.73	10.17	11.25	7.55	6.70	50	3.90	3.82	4.04	4.60	3.22	3.51	3.24	3.45	3.35	3.60	50
(21) MO	6.18	6.26	5.59	7.66	6.92	8.88	9.11	7.79	9.51	9.76	9.61	5.51	5.20	4.71	7.90	9.58	11.07	7.41	6.40	3.37	0.07	3.85	3.73	4.29	3.30	3.49	3.52	3.84	4.37	3.84	
(22) AR-LA	8.03	7.63	6.80	8.78	8.76	10.95	11.15	9.02	10.58	10.63	9.72	5.27	5.39	6.08	10.15	12.36	13.54	10.74	9.30	5.81	6.35	51	4.35	4.95	4.97	4.74	5.02	5.81	6.55	5.83	51
(23) FL																							104								104
(24) MS-AL-GA																							2.87	241	2.13	3.11	3.02	4.55	4.45	3.93	241
(25) NC-SC																							5.84	7.32	127	6.94	4.48	7.69	7.24	5.92	127
(26) KY-TN																							4.10	3.92	2.57	149	3.18	4.38	4.70	4.13	149
(27) VA-WVA-MD-DE																							6.66	8.24	4.84	7.66	73	7.84	5.40	5.16	73
(28) MI-IN-OH																							4.93	5.60	3.80	4.62	3.58	0.62	4.32	3.76	
(29) PA																							6.01	7.43	5.47	6.91	3.26	6.54	269	3.50	269
(30) North East																														255	255
Total	162	243	472	72	56	45	76	28	37	18	80	102	133	61	56	36	29	207	62	261	113	127	269	241	188	167	280	557	269	955	5422

*Underscored figures are shipments (in million pounds). Other figures are opportunity costs (in dollars per hundredweight) which result from not having an activity in the optimum solution.

Table 15. Model 3 - Optimum shipments of beef, with initial start-up merchandising costs, by packaging/distribution system, 1988.

Packaging/distribution system	Beef shipped (million pounds)
Boxed beef:	
Domestic market	5,954
Export market	494
Central vacuum	6,696
HRI	5,422
Total shipped	18,566

fornia, Southeast Texas, and Kentucky-Tennessee. Five surplus regions, including Nebraska, Minnesota-Wisconsin, Kansas, Iowa, and Colorado, competed for the large deficit beef market in the Northeast. Although Colorado shipped central vacuum packaged beef to the Northeast, most of the vacuum-packaged beef shipped from Colorado was destined for Northern California.

The distribution pattern of boxed beef versus vacuum-packaged beef in Figure 6 is impacted, to a large degree, by regional labor cost differentials. Regions receiving vacuum-packaged beef, both on an interregional and intraregional basis, generally exhibited higher retail labor costs compared to regions receiving boxed beef, Table 1. These results suggest that regions receiving vacuum-packaged beef found it economical for beef to be fabricated and packaged into vacuum packaging at the packer/fabrication level compared to receiving beef as boxed beef for further fabrication in those regions with relatively high wage rates. For example, regions with relatively high retail wage rates such as Houston (Region 12), received central-vacuum beef rather than boxed beef.

HRI. Under the conditions imposed by Model 3, 51 percent of the HRI-beef demand was filled from intrastate sources, Figure 7 and Table 18. Six regions shipped surplus HRI beef on an interregional basis. Nebraska, which accounted for 73 percent of the interregional HRI shipments, merchandised HRI beef in the Southeast, the Atlantic Coast states, and the Northeast. The Texas-Oklahoma Panhandle and South Texas shipped HRI beef to nearby markets to the east and southeast of these regions. The Texas-Oklahoma Panhandle's next best market was Florida with an opportunity cost of only $0.30 per hundredweight. West Texas competed with Arizona for the Southern California market. North Dakota-South Dakota shipped its surplus HRI beef to Washington-Oregon.

Impact of Short-run Adjustments in Merchandising Costs on Alternative

Figure 6. Optimal distribution of boxed beef and vacuum-packaged beef with initial start-up merchandising costs (Model 3).

Table 16. Model 3 - Optimum shipments of boxed beef and opportunity shipping costs, with initial start-up merchandising costs, by region, 1988.

Originating Region/Area	Destination Region* (1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)	(13)	(14)	(15)	(16)	(17)	(18)	(19)	(20)	(21)	(22)	(23)	(24)	(25)	(26)	(27)	(28)	(29)	(30)	(31)	Total Shipped
(1) WA-OR	377	7.23	4.83	3.70	6.17																										0.23	377
(2) N.CA	6.28	4.55	5.40	4.76	7.88																										2.24	
(3) S.CA	6.37	7.90	1.02	3.43	7.32																										2.55	
(4) AZ	7.22	9.15	5.24	0.17	7.63																										4.98	
(5) UT-NV	3.07	5.72	2.66	1.09	130																										63	193
(6) MT-ID-WY	2.55	6.08	3.21	1.62	3.54	104	5.62	2.23	6.03	4.15	2.94	2.70	2.83	3.16	6.18	4.33	3.97	8.84	4.86	4.21	2.31	2.24	1.77	1.96	2.25	2.50	4.62	1.65	1.92	3.17	261	365
(7) CO	2.55	5.28	2.10	38	2.60	3.38	177	27	3.37	2.01	0.62	0.41	0.43	0.68	3.60	1.90	2.83	7.40	2.99	2.20	0.24	0.16	0.06	0.12	0.19	0.58	2.79	0.02	0.14	1.47	170	412
(8) NM	7.69	9.94	6.35	4.15	7.67	8.62	8.63	1.12	7.89	6.00	5.08	4.97	5.04	5.40	8.71	7.69	8.46	12.80	8.41	7.44	5.40	4.83	4.74	4.94	5.15	5.53	7.85	5.15	5.39	6.64	6.18	
(9) TX-OK PAN.	3.70	6.01	2.48	0.32	3.82	4.53	4.22	0.14	87	1.99	0.26	0.12	223	0.30	3.72	2.70	4.08	8.09	3.67	2.73	0.65	53	0.05	0.19	0.31	0.80	3.03	0.51	0.50	1.89	2.57	363
(10) W.TX	5.40	7.40	3.68	1.39	5.51	6.37	6.46	1.82	5.59	43	2.12	2.15	2.34	3.04	6.31	5.45	6.13	10.31	5.93	5.05	2.93	2.15	2.11	2.31	2.54	2.97	5.29	2.68	2.80	4.22	2.92	43
(11) S.TX	8.11	10.34	6.76	4.56	8.29	9.03	9.03	4.89	7.90	6.13	187	2.88	3.58	4.68	8.18	7.32	8.42	12.25	7.78	6.84	4.72	3.54	3.62	3.84	3.92	4.59	6.84	4.44	4.54	5.90	5.02	187
(12) SE.TX	10.27	12.61	9.06	6.88	10.48	11.17	11.20	7.15	10.15	8.52	5.27	1.70	5.52	6.68	10.21	9.44	10.42	14.27	9.78	8.68	6.65	5.28	5.38	5.61	5.76	6.44	8.52	6.34	6.20	7.63	6.48	
(13) E.TX	7.84	10.22	6.69	4.52	8.07	8.72	8.65	4.66	7.43	6.14	3.37	2.92	89	3.85	7.50	6.85	7.90	11.78	7.25	6.30	4.14	3.00	3.36	3.44	3.46	4.13	6.33	4.04	3.96	5.39	4.51	89
(14) E.OK	7.09	9.53	6.03	3.86	7.27	7.91	7.76	3.87	6.57	5.66	3.32	2.93	2.69	87	6.26	5.82	6.97	10.99	6.44	5.51	3.29	2.81	2.93	2.96	2.99	3.55	5.77	3.29	3.15	4.69	3.97	87
(15) KS	3.88	6.47	2.96	0.86	4.02	4.68	4.44	0.91	3.73	2.66	0.55	0.19	0.08	54	0.03	2.29	3.55	7.61	3.01	2.17	170	244	627	489	439	0.43	2.61	299	0.12	1.49	2.45	2321
(16) NE	5.15	7.90	4.85	2.80	5.34	5.96	5.86	2.96	5.81	4.86	2.79	2.52	2.53	2.66	5.39	0.25	4.67	8.90	4.40	3.93	1.91	2.20	1.89	1.93	1.86	2.34	4.36	1.65	1.66	3.05	4.71	
(17) ND-SD	4.13	7.43	4.44	2.61	5.02	4.78	5.88	2.82	6.32	4.65	3.03	2.63	2.72	2.94	5.78	3.79	67	8.30	4.60	3.93	2.13	2.25	1.76	1.94	1.97	2.33	4.24	1.43	1.50	2.81	1.95	67
(18) MN-WI	4.07	7.19	4.18	2.10	4.72	4.67	5.43	2.26	5.38	3.97	1.97	1.59	1.64	1.96	4.78	2.89	3.15	4.01	3.03	2.48	0.71	1.55	0.58	0.69	0.36	1.03	2.78	0.05	0.02	1.40	1.19	
(19) IA	4.33	7.13	4.03	1.94	4.62	4.98	5.26	2.11	5.16	3.83	1.70	1.29	1.29	1.58	4.35	2.59	3.82	7.30	145	2.20	0.33	0.88	0.52	0.53	0.32	0.83	2.73	440	354	1.43	1.61	939
(20) IL	8.15	10.92	7.72	5.48	8.46	8.85	8.97	5.62	8.73	7.44	5.26	4.66	4.84	5.16	8.03	6.72	7.70	11.23	6.68	2.38	3.57	3.81	3.65	3.57	3.07	3.74	5.58	3.01	3.10	4.52	4.64	
(21) MO	7.44	10.22	6.85	4.72	7.74	8.22	8.28	4.84	7.87	6.57	4.36	3.87	3.88	4.14	7.07	5.92	7.18	10.73	6.09	4.85	95	3.43	3.04	2.97	2.73	3.33	5.37	2.87	2.71	4.28	4.49	95
(22) AR-LA	11.27	13.73	10.25	8.06	11.57	12.19	12.23	8.25	11.19	9.75	7.03	6.31	6.61	7.66	11.17	10.38	11.43	15.55	10.62	9.07	7.41	2.84	6.05	6.01	6.44	6.77	8.97	6.79	6.77	8.21	7.78	
(23) FL																							5.83								11.30	
(24) MS-AL-GA																							2.98	74	2.46	3.59	5.55	3.86	3.28	4.85	4.45	74
(25) NC-SC																							8.49	9.03	3.95	9.67	10.05	9.48	8.67	9.71	9.01	
(26) KY-TN																							4.46	3.89	3.40	1.55	6.30	4.40	4.10	5.64	5.77	
(27) VA-WVA-MD-DE																							11.85	12.45	10.60	12.96	9.26	12.39	10.25	12.01	12.28	
(28) MI-IN-OH																							3.72	3.72	2.94	3.97	5.29	562	2.56	4.11	4.27	562
(29) PA																							5.37	5.87	4.98	6.43	6.01	5.49	274	4.86	4.50	274
(30) North East																														1.98	0.00	
Total	377			38	130	104	177	27	87	43	187		312	141			67		145		265	297	627	563	439			1300	628		494	6448

*Underscored figures are shipments (in million pounds). Other figures are opportunity costs (in dollars per hundredweight) which result from not having an activity in the optimum solution.

Table 17. Model 3 - Optimum shipments of central-vacuum beef and opportunity shipping costs, with initial start-up merchandising costs, by region, 1988.

Originating	Destination Region*																													Total
Region/Area	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)	(13)	(14)	(15)	(16)	(17)	(18)	(19)	(20)	(21)	(22)	(23)	(24)	(25)	(26)	(27)	(28)	(29)	(30)	Shipped
(1) WA-OR	0.34	3.83	4.62	7.27	9.03																										
(2) N.CA	5.47	150	4.04	7.17	9.59																										150
(3) S.CA	5.92	3.70	262	6.19	9.37																										262
(4) AZ	3.83	2.01	1.29	130	6.75																										130
(5) UT-NV	2.64	1.55	1.68	3.88	2.09																										
(6) MT-ID-WY	1.38	1.17	1.49	3.67	4.88	3.43	7.18	3.52	8.85	6.18	6.65	3.35	3.90	7.23	6.54	6.04	5.92	5.14	6.54	2.44	4.44	6.64	3.47	5.77	5.69	2.45	2.40	2.59	5.21	2.07	
(7) CO	1.02	418	0.01	1.68	3.57	6.44	1.18	0.91	5.82	3.66	3.96	0.69	1.13	4.38	3.58	3.24	4.41	3.33	4.30	0.06	2.00	4.18	1.39	3.54	3.25	0.17	0.20	0.59	3.06	267	685
(8) NM	4.12	2.62	2.22	3.79	6.61	9.64	7.77	38	8.30	5.61	6.38	3.20	3.71	7.06	6.65	6.99	8.00	6.69	7.67	3.26	5.12	6.82	4.04	6.32	6.18	3.08	3.21	3.69	6.27	3.14	38
(9) TX-OK PAN.	1.78	0.34	838	1.61	4.40	7.20	5.02	0.67	2.06	3.25	3.21	236	0.31	3.61	3.31	3.65	5.27	3.63	4.58	0.21	2.03	3.64	0.99	3.22	2.99	390	0.05	0.70	3.02	0.04	1464
(10) W.TX	2.60	0.85	0.33	1.81	5.22	8.17	6.39	1.48	6.78	0.39	4.20	1.16	1.79	5.48	5.03	5.53	6.45	4.96	5.98	1.65	3.43	4.92	2.18	4.46	4.34	1.30	1.43	2.00	4.45	1.50	
(11) S.TX	4.33	2.81	2.42	4.00	7.02	9.84	7.97	3.56	8.11	5.54	1.10	0.91	2.03	6.14	5.92	6.41	7.76	5.94	6.84	2.46	4.24	5.32	2.70	5.01	4.74	1.93	2.00	2.77	5.21	2.19	
(12) SE.TX	7.49	6.09	5.72	7.32	10.21	12.98	11.15	6.83	11.35	8.93	7.36	0.73	4.98	9.14	8.95	9.53	10.76	8.95	9.83	5.30	7.16	8.06	5.46	7.78	7.59	4.78	4.68	5.67	7.87	4.92	
(13) E.TX	6.08	4.71	4.38	5.96	8.82	11.55	9.61	5.35	9.65	7.56	6.48	2.97	0.48	7.33	7.26	7.96	9.26	7.49	8.33	3.94	5.67	6.81	4.46	6.63	6.30	3.48	3.51	4.39	6.65	3.70	
(14) E.OK	5.95	4.65	4.33	5.94	8.64	11.36	9.35	5.18	9.41	7.71	7.05	3.60	3.79	4.10	6.64	7.55	8.95	7.31	8.14	3.77	5.45	7.23	4.66	6.79	6.46	3.53	3.57	4.26	6.46	3.62	
(15) KS	2.33	1.17	0.85	2.53	4.96	7.72	5.61	1.81	6.16	4.30	3.87	0.45	0.77	3.69	130	3.62	5.12	3.52	4.29	0.01	1.75	4.01	1.31	3.40	3.05	0.00	653	0.56	3.02	129	912
(16) NE	2.03	1.03	1.17	2.90	4.73	7.43	5.46	2.26	6.67	4.93	4.54	1.20	1.64	4.77	3.79	83	4.66	3.24	4.12	0.21	2.08	4.63	1.63	3.76	3.34	0.34	0.18	0.64	2.99	994	1077
(17) ND-SD	1.25	0.81	1.00	2.96	4.65	6.49	5.72	2.39	7.42	4.95	5.01	1.56	2.07	5.29	4.42	3.79	0.23	2.88	4.56	0.44	2.54	4.93	1.74	4.01	3.69	0.57	0.30	0.66	3.07	267	267
(18) MN-WI	2.60	1.97	2.14	3.84	5.76	7.79	6.68	3.24	7.89	5.68	5.37	1.92	2.40	5.72	4.82	4.29	4.79	483	4.40	0.41	2.53	5.64	1.97	4.17	3.49	0.67	0.25	0.69	3.00	572	1055
(19) IA	3.03	2.08	2.17	3.86	5.83	8.27	6.68	3.26	7.84	5.72	5.27	1.80	2.23	5.52	4.57	4.16	5.63	3.46	1.53	0.30	2.32	5.14	2.08	4.18	3.62	0.65	0.37	0.81	3.15	0.20	
(20) IL	6.37	5.40	5.38	6.92	9.19	11.66	9.91	6.30	10.94	8.85	8.35	4.69	5.30	8.62	7.77	7.81	9.04	6.91	7.74	656	5.09	7.60	4.74	6.75	5.90	3.09	2.75	3.35	5.77	2.81	656
(21) MO	5.77	4.81	4.63	6.27	8.59	11.15	9.33	5.62	10.19	8.09	7.56	4.01	4.45	7.71	6.93	7.13	8.63	6.53	7.26	2.58	1.63	7.32	4.24	6.25	5.66	2.79	2.64	3.32	5.50	2.68	
(22) AR-LA	8.36	7.08	6.79	8.37	11.17	13.88	12.05	7.80	12.27	10.03	8.99	5.21	5.94	9.99	9.79	10.34	11.63	10.11	10.55	5.56	7.80	5.49	6.01	8.05	8.13	4.98	5.00	5.99	8.31	5.37	
(23) FL																							4.29								
(24) MS-AL-GA																							3.73	2.83	4.94	2.59	2.37	3.85	5.61	2.80	
(25) NC-SC																							8.19	10.82	5.38	7.62	5.83	8.43	9.95	6.61	
(26) KY-TN																							5.23	6.75	5.92	0.58	3.16	4.42	6.46	3.62	
(27) VA-WVA-MD-DE																							10.06	12.75	10.55	9.43	3.55	9.85	10.05	7.42	
(28) MI-IN-OH																							5.54	7.62	6.49	4.04	3.18	1.06	5.96	3.12	
(29) PA																							6.54	9.13	7.89	5.85	3.26	5.91	2.76	3.24	
(30) North East																														0.73	
Total		568	1100	130				38				236			130	83		483		656						390	653			2229	6696

*Underscored figures are shipments (in million pounds). Other figures are opportunity costs (in dollars per hundredweight) which result from not having an activity in the optimum solution.

Table 18. Model 3 - Optimum shipments of HRI beef and opportunity shipping costs, with initial start-up merchandising costs, by region, 1988.

Originating Region/Area	Destination Region*																													Total Shipped
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)	(13)	(14)	(15)	(16)	(17)	(18)	(19)	(20)	(21)	(22)	(23)	(24)	(25)	(26)	(27)	(28)	(29)	(30)	
(1) WA-OR	135	6.15	7.17	12.14	8.92																										135
(2) N.CA	5.49	243	5.00	10.70	8.46																										243
(3) S.CA	6.52	5.02	0.23	9.60	8.51																										
(4) AZ	2.15	1.25	24	72	3.34																										96
(5) UT-NV	3.11	3.29	3.31	7.62	56																										56
(6) MT-ID-WY	1.05	2.55	2.87	7.14	3.10	45	7.62	7.07	9.25	8.87	9.92	6.18	5.95	5.43	8.75	9.39	8.46	6.78	6.57	4.61	4.84	4.49	4.01	5.58	4.79	4.43	4.59	4.19	5.58	4.37	45
(7) CO	0.93	1.23	1.07	4.59	1.57	4.00	76	3.60	5.13	5.52	6.31	2.62	2.23	1.58	4.74	5.61	6.62	4.49	3.64	1.47	1.61	1.24	1.33	2.67	1.56	1.43	1.72	1.62	2.78	1.69	76
(8) NM	2.43	2.00	1.23	4.60	2.97	5.65	5.79	28	5.70	5.29	6.78	3.24	2.94	2.45	6.20	8.08	8.85	6.38	5.55	3.12	3.13	2.04	2.14	3.68	2.81	2.64	3.10	3.11	4.45	3.25	28
(9) TX-OK PAN.	1.65	1.31	0.63	4.06	2.39	4.72	4.39	2.80	37	4.48	4.76	1.17	0.57	61	3.91	5.80	7.48	4.52	3.64	1.26	1.22	15	0.30	1.76	0.74	0.75	1.07	1.36	2.30	1.32	113
(10) W.TX	1.76	0.96	448	3.24	2.49	5.05	5.32	2.89	5.02	18	5.12	1.79	1.66	1.68	5.37	7.49	8.13	5.42	4.61	2.30	2.20	0.79	0.95	2.51	1.65	1.58	2.03	2.18	3.32	2.38	466
(11) S.TX	2.95	2.50	1.74	5.12	3.79	6.16	6.30	4.62	5.61	5.39	80	81	0.64	1.27	5.30	7.42	8.69	5.46	4.50	2.12	2.02	61	0.34	1.94	0.85	1.13	1.48	1.95	3.06	2.03	222
(12) SE.TX	7.03	6.75	6.03	9.44	7.92	10.21	10.40	8.86	9.82	9.82	7.81	21	4.39	5.12	9.19	11.45	12.53	9.32	8.34	5.72	5.75	3.44	3.83	5.42	4.45	4.75	4.84	5.63	6.40	5.48	21
(13) E.TX	6.34	6.12	5.45	8.86	7.26	9.49	9.53	8.07	8.70	9.20	7.91	3.87	133	3.82	8.09	10.52	11.72	8.55	7.51	5.11	4.94	2.99	3.75	5.13	3.95	4.23	4.52	5.15	5.99	5.07	133
(14) E.OK	6.66	6.52	5.88	9.30	7.50	9.72	9.63	8.33	8.85	9.93	9.27	5.31	4.54	0.41	7.66	10.41	11.75	8.80	7.72	5.36	5.11	4.14	4.55	5.88	4.70	4.80	5.12	5.45	6.21	5.45	
(15) KS	2.59	2.68	2.03	5.55	3.37	5.62	5.40	4.63	5.33	6.17	5.87	1.96	1.38	0.23	56	5.87	7.37	4.47	3.33	1.09	0.92	0.67	0.90	2.15	0.95	0.87	1.13	1.27	2.41	1.39	56
(16) NE	0.75	1.09	1.12	4.72	1.61	3.81	3.79	3.96	4.72	5.73	5.49	1.71	1.31	0.47	3.37	36	5.30	2.66	1.68	231	0.04	0.22	165	1.31	61	18	207	557	0.98	700	1975
(17) ND-SD	27	1.16	1.29	5.20	1.90	2.80	4.59	4.53	6.25	6.18	6.61	2.65	2.36	1.67	4.72	5.15	29	2.53	2.75	0.76	1.14	1.07	0.57	2.09	0.94	0.76	0.59	0.45	1.52	0.40	56
(18) MN-WI	2.89	3.78	3.86	7.41	4.43	5.62	6.89	6.67	7.82	8.14	8.01	4.07	3.72	3.17	6.19	6.77	6.78	207	3.37	1.57	1.99	3.00	1.79	3.20	1.50	1.78	1.39	1.35	2.27	1.27	207
(19) IA	3.53	3.93	3.90	7.43	4.53	6.33	6.88	6.69	7.75	8.18	7.85	3.87	3.45	2.88	5.80	6.57	8.03	4.27	62	1.41	1.68	2.25	1.94	3.21	1.69	1.73	1.57	1.52	2.50	1.57	62
(20) IL	6.67	7.02	6.83	10.15	7.70	9.54	9.86	9.37	10.51	11.00	10.60	6.33	6.18	5.64	8.73	10.18	11.26	7.57	6.51	50	3.94	4.06	4.04	5.18	3.23	3.51	3.25	3.45	4.55	3.61	50
(21) MO	6.07	6.45	6.01	9.48	7.10	9.08	9.30	8.67	9.70	10.18	9.73	5.62	5.22	4.59	7.78	9.47	10.96	7.31	6.10	3.26	113	3.96	3.61	4.75	3.19	3.37	3.41	3.73	4.46	3.72	113
(22) AR-LA	7.81	7.71	7.11	10.49	8.83	11.03	11.23	9.79	10.67	10.94	9.73	5.28	5.31	5.86	9.92	12.14	13.32	10.53	8.88	5.59	6.17	51	4.12	5.31	4.75	4.51	4.80	5.59	6.53	5.61	51
(23) FL																							104								104
(24) MS-AL-GA																							2.30	241	1.56	2.53	2.45	3.97	4.08	3.35	241
(25) NC-SC																							5.83	7.90	127	6.93	4.48	7.68	7.44	5.92	127
(26) KY-TN																							4.11	4.50	2.58	149	3.19	4.39	4.91	4.14	149
(27) VA-WVA-MD-DE																							6.65	8.81	4.84	7.66	73	7.83	5.59	5.15	73
(28) MI-IN-OH																							5.43	6.68	4.31	5.13	4.09	1.13	5.02	4.26	
(29) PA																							5.80	7.80	5.27	6.71	3.06	6.34	269	3.30	269
(30) North East																														255	255
Total	162	243	472	72	56	45	76	28	37	18	80	102	133	61	56	36	29	207	62	281	113	127	269	241	188	167	280	557	269	955	5422

*Underscored figures are shipments (in million pounds). Other figures are opportunity costs (in dollars per hundredweight) which result from not having an activity in the optimum solution.

Figure 7. Optimal distribution of HRI beef with initial start-up merchandising costs (Model 3).

Packaging/Distribution Systems

Of paramount importance to the retailing industry is the impact of short-run adjustment in merchandising and associated costs on packaging/distribution systems following the impact of the initial start-up merchandising costs as estimated in Model 3. Model 4 contains all of the assumptions of Model 3, except that costs associated with such items as advertising, labor, and promotions are assumed to decline by $3.00 per hundredweight as consumers begin adjusting to case-ready beef systems.

Table 19 shows that three packaging/distribution systems accounted for the non-HRI domestic beef merchandised in the U.S. Central vacuum accounted for 83 percent of the total, followed by boxed beef with 14 percent, and tray-ready with 3 percent.

Central Vacuum. Costs were minimized when more than 62 percent of the central-vacuum-packaged beef, which accounted for 83 percent of the non-HRI domestic beef merchandised, was shipped on an interregional basis, Table 20 and Figure 8. The major out-of-state shippers of central-vacuum beef were Kansas and Texas-Oklahoma Panhandle, followed by Nebraska, Colorado, and Minnesota-Wisconsin.

Given the short-run adjustment in merchandising costs in Model 4, the regional distributional pattern of vacuum-packaged beef versus boxed beef underwent additional changes from Model 3 to Model 4. Figure 8 shows that with a $3.00 decrease in merchandising costs over all alternative packaging/distribution systems, Florida, East Texas, New Mexico, and Arizona found it economical to purchase vacuum-packaged beef rather than boxed beef.

Major markets for vacuum-packaged beef for Kansas were the Atlantic Coast states and the Northeast, Figure 8 and Table 20. Nebraska was a major source of vacuum-packaged beef for the Northeast, along with Minnesota-Wisconsin, Iowa,

Table 19. Model 4 - Optimum shipments of beef, with short-run adjustments in merchandising costs, by beef packaging/distribution system, 1988.

Packaging/distribution system	Beef shipped (million pounds)
Boxed beef:	
Domestic market	1,740
Export market	494
Tray-ready	377
Central vacuum	10,532
HRI	5,422
Total shipped	18,565

Figure 8. Optimal distribution of vacuum packaged beef, boxed beef, and tray-ready beef with short-run adjustments in merchandising costs (Model 4)

North Dakota-South Dakota, and Kansas.

Primary interregional markets for vacuum packaged beef from the Texas-Oklahoma Panhandle were Florida, Southeast Texas, East Texas, the Southwest, and Southern California. Surplus vacuum-packaged beef from Colorado was shipped to Northern California and to Southern California in competition with the Texas-Oklahoma Panhandle.

Boxed Beef. Out-of-state domestic shipments of boxed beef in Model 4 originated from Kansas and Iowa, Figure 8 and Table 21. Kansas shipped boxed beef southeast to Eastern Oklahoma, Arkansas-Louisiana, Mississippi-Alabama-Georgia, and North Carolina-South Carolina. Although North Carolina-South Carolina purchased most of its beef as boxed beef from Kansas, the region also obtained some beef as vacuum-packaged beef from the Texas-Oklahoma Panhandle. Iowa shipped its boxed beef east to Pennsylvania. The export demand for U.S. beef was satisfied by shipments of boxed beef from Montana-Idaho-Wyoming, Colorado, and Utah-Nevada.

Tray-ready. Tray-ready beef represented about 3 percent of the non-HRI domestic beef shipments in Model 4, Table 22. Total system costs were minimized when the non-HRI beef consumed within Washington-Oregon was obtained from Washington-Oregon sources as tray-ready beef, Figure 8.

HRI. More than 50 percent of the HRI beef requirements in Model 4 were obtained on an intraregional basis or from suppliers within their own respective regions. Regions shipping HRI beef on an interregional basis were Nebraska, West Texas, South Texas, Texas-Oklahoma Panhandle, and North Dakota-South Dakota, Figure 9 and Table 23.

Nebraska continued to ship HRI beef to the Southeast, the East, and Northeast in Model 4 as it did in Model 3, Figure 9. West Texas was the sole out-of-state supplier of HRI beef to Southern California. The shipment patterns for South Texas, Texas-Oklahoma Panhandle, and North Dakota-South Dakota in Model 4 were similar to those in Model 3.

Impact of Intermediate-run and Long-run Adjustments in Total Costs on Alternative

Table 20. Model 4 - Optimum shipments of central-vacuum beef and opportunity shipping costs, with short-run adjustments in merchandising costs, by region, 1988.

Originating Region/Area	Destination Region* (1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)	(13)	(14)	(15)	(16)	(17)	(18)	(19)	(20)	(21)	(22)	(23)	(24)	(25)	(26)	(27)	(28)	(29)	(30)	Total Shipped
(1) WA-OR	0.00	3.83	4.61	5.65	6.94																										
(2) N.CA	5.13	150	4.03	5.55	7.50																										150
(3) S.CA	5.59	3.71	238	4.58	7.29																										238
(4) AZ	5.11	3.63	2.90	154	6.28																										154
(5) UT-NV	2.30	1.55	1.67	2.26	130																										130
(6) MT-ID-WY	1.04	1.17	1.48	2.05	2.79	0.43	6.00	2.84	6.78	5.55	5.54	3.34	3.58	4.23	6.54	6.04	5.69	5.14	5.21	2.44	2.69	3.64	2.47	2.77	2.69	2.45	2.40	2.03	2.41	2.07	
(7) CO	0.68	418	332	0.06	1.48	3.44	177	0.23	3.75	3.03	2.85	0.68	0.81	1.38	3.58	3.24	4.18	3.33	2.97	0.06	0.25	1.18	0.39	0.54	0.25	0.17	0.20	0.03	0.26	0.00	927
(8) NM	4.46	3.30	2.89	2.85	5.20	7.32	7.27	38	6.91	5.66	5.95	3.87	4.07	4.74	7.33	7.67	8.45	7.37	7.02	3.94	4.05	4.50	3.72	4.00	3.86	3.76	3.89	3.81	4.15	3.82	38
(9) TX-OK PAN.	1.45	0.35	530	14	2.32	4.21	3.85	27	87	32.63	2.11	236	223	0.62	3.32	3.66	5.05	3.64	3.26	0.22	0.29	0.65	627	0.23	83	0.01	0.06	0.15	0.23	0.05	1827
(10) W. TX	2.50	1.09	0.56	0.43	3.37	5.41	5.45	1.04	4.95	43	3.33	1.39	1.71	2.72	5.27	5.77	6.46	5.22	4.89	1.89	1.92	2.16	1.42	1.70	1.58	1.54	1.67	1.68	1.89	1.74	43
(11) S.TX	4.00	2.82	2.42	2.39	4.94	6.85	6.80	2.89	6.05	4.92	187	0.91	1.72	3.15	5.93	6.42	7.54	5.95	5.52	2.47	2.50	2.33	1.71	2.02	1.75	1.94	2.01	2.22	2.42	2.20	187
(12) SE.TX	7.16	6.10	5.72	5.71	8.13	9.99	9.96	6.16	9.29	8.31	6.26	0.73	4.67	6.15	8.96	9.54	10.54	8.96	8.51	5.31	5.42	5.07	4.47	4.79	4.60	4.79	4.69	5.12	5.08	4.93	
(13) E.TX	5.58	4.55	4.21	4.20	6.57	8.39	8.27	4.51	7.42	6.77	5.21	2.80	89	4.17	7.10	7.80	8.87	7.33	6.84	3.78	3.76	3.65	3.30	3.47	3.14	3.32	3.35	3.67	3.69	3.54	89
(14) E.OK	5.61	4.65	4.32	4.32	6.55	8.36	8.17	4.50	7.34	7.08	5.94	3.59	3.47	1.10	6.64	7.55	8.72	7.31	6.81	3.77	3.70	4.23	3.66	3.79	3.46	3.53	3.57	3.70	3.66	3.62	
(15) KS	1.99	1.17	0.84	0.91	2.89	4.72	4.43	1.13	4.09	3.67	2.76	0.44	0.45	0.69	130	3.62	4.89	3.52	2.96	0.01	56	1.01	0.31	0.40	0.05	390	653	739	0.22	69	2037
(16) NE	1.69	1.03	1.16	1.28	2.64	4.43	4.28	1.60	4.60	4.30	3.43	1.19	1.32	1.77	3.79	83	4.43	3.24	2.79	0.21	0.33	1.63	0.63	0.76	034	0.34	0.18	0.08	0.19	881	964
(17) ND-SD	0.91	0.81	0.99	1.33	2.56	3.49	4.54	1.71	5.35	4.32	3.90	1.55	1.75	2.29	4.42	3.79	67	2.88	3.23	0.44	0.79	1.93	0.74	1.01	0.69	0.57	0.30	0.10	0.27	267	334
(18) MN-WI	2.26	1.97	2.13	2.22	3.67	4.79	5.50	2.56	5.82	5.05	4.26	1.91	2.08	2.72	4.82	4.29	4.56	483	3.07	0.41	0.78	2.64	0.97	1.17	0.49	0.67	0.25	0.13	0.20	572	1055
(19) IA	2.49	1.88	1.96	2.04	3.54	5.07	5.30	2.38	5.57	4.89	3.96	1.59	1.71	2.32	4.37	3.96	5.20	3.26	145	0.10	0.37	1.94	0.88	0.98	0.42	0.45	0.17	0.05	0.15	440	585
(20) IL	6.03	5.40	5.37	5.30	7.10	8.66	8.73	5.62	8.87	8.22	7.24	4.68	4.98	5.62	7.77	7.81	8.81	6.91	6.41	656	3.34	4.60	3.74	3.75	2.90	3.09	2.75	2.79	2.97	2.81	656
(21) MO	5.55	4.93	4.74	4.77	6.62	8.27	8.27	5.06	8.24	7.58	6.57	4.12	4.25	4.83	7.05	7.25	8.52	6.65	6.05	2.70	208	4.44	3.36	3.37	2.78	2.91	2.76	2.88	2.82	2.80	208
(22) AR-LA	8.03	7.09	6.79	6.76	9.09	10.89	10.88	7.13	10.21	9.41	7.89	5.21	5.63	7.00	9.80	10.35	11.41	10.12	9.23	5.57	6.06	2.50	5.02	5.06	5.14	4.99	5.01	5.44	5.52	5.38	
(23) FL																							3.29								
(24) MS-AL-GA																							2.90	74	2.11	2.76	2.54	3.46	2.98	2.97	74
(25) NC-SC																							7.19	7.82	2.38	7.62	5.83	7.87	7.15	6.61	
(26) KY-TN																							4.23	3.75	2.92	0.58	3.16	3.86	3.66	3.62	
(27) VA-WVA-MD-DE																							9.06	9.75	7.55	9.43	3.55	9.29	7.25	7.42	
(28) MI-IN-OH																							4.04	4.12	2.99	3.54	2.68	562	2.66	2.62	562
(29) PA																							5.58	6.17	4.93	5.89	3.30	5.39	274	3.28	274
(30) North East																														0.73	
Total		568	1100	168	130		177	65	87	43	187	236	312		130	83	67	483	145	656	264		627	74	83	390	653	1301	274	2229	10532

*Underscored figures are shipments (in million pounds). Other figures are opportunity costs (in dollars per hundredweight) which result from not having an activity in the optimum solution.

Table 21. Model 4 - Optimum shipments of boxed beef and opportunity shipping costs, with short-run adjustments in merchandising costs, by region, 1988.

Originating	Destination Region*																														Total
Region/Area	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)	(13)	(14)	(15)	(16)	(17)	(18)	(19)	(20)	(21)	(22)	(23)	(24)	(25)	(26)	(27)	(28)	(29)	(30)	(31)	Shipped
(1) WA-OR	2.66	10.23	7.82	5.08	7.08																										0.23	
(2) N.CA	8.94	7.55	8.39	6.14	8.79																										2.24	
(3) S.CA	9.04	10.91	4.02	4.82	8.24																										2.56	
(4) AZ	11.50	13.77	9.85	3.17	10.16																										6.60	
(5) UT-NV	5.73	8.72	5.65	2.47	0.91																										63	63
(6) MT-ID-WY	5.21	9.08	6.20	3.00	4.45	104	7.44	4.55	6.96	6.52	4.83	5.69	5.51	3.16	9.18	7.33	6.74	11.84	6.53	7.21	3.56	2.24	3.77	1.98	2.25	5.50	7.62	4.09	2.12	6.17	261	365
(7) CO	5.21	8.28	5.09	1.38	3.51	3.38	1.82	2.32	4.30	4.38	2.51	3.40	3.11	0.68	6.60	4.90	5.60	10.40	4.66	5.20	1.49	0.16	2.06	0.12	0.19	3.58	5.79	2.46	0.34	4.47	170	170
(8) NM	11.03	13.62	10.02	6.21	9.26	9.30	11.13	4.12	9.50	9.05	7.65	8.64	8.40	6.08	12.39	11.37	11.91	16.48	10.76	11.12	7.33	5.51	7.42	5.62	5.83	9.21	11.53	8.27	6.27	10.32	6.86	
(9) TX-OK PAN.	6.37	9.02	5.48	1.71	4.74	4.54	6.05	2.47	0.94	4.37	2.16	3.12	2.69	0.31	6.73	5.71	6.86	11.10	5.35	5.74	1.91	0.01	2.06	0.20	0.32	3.81	6.04	2.96	0.71	4.90	2.58	
(10) W.TX	8.30	10.64	6.91	3.01	6.66	6.61	8.52	4.38	6.76	2.61	4.25	5.38	5.26	3.28	9.55	8.69	9.14	13.55	7.84	8.29	4.42	2.39	4.35	2.55	2.78	6.21	8.53	5.36	3.24	7.46	3.16	
(11) S.TX	10.78	13.35	9.76	5.95	9.21	9.04	10.86	7.22	8.84	8.51	1.90	5.88	6.27	4.69	11.19	10.33	11.20	15.26	9.46	9.85	5.95	3.55	5.63	3.85	3.93	7.60	9.85	6.89	4.75	8.91	5.03	
(12) SE.TX	12.94	15.62	12.06	8.27	11.40	11.18	13.03	9.48	11.09	10.90	7.17	4.70	8.21	6.69	13.22	12.45	13.20	17.26	11.46	11.69	7.91	5.29	7.39	5.62	5.77	9.45	11.53	8.79	6.41	10.64	6.49	
(13) E.TX	10.34	13.06	9.52	5.74	8.82	8.56	10.31	6.82	8.20	8.35	5.10	5.75	2.52	3.69	10.34	9.69	10.51	14.62	8.76	9.14	5.23	2.84	5.20	3.28	3.30	6.97	9.17	6.32	4.00	8.23	4.35	
(14) E.OK	9.75	12.53	9.02	5.24	8.18	7.91	9.58	6.19	7.50	8.03	5.21	5.92	5.37	87	9.26	8.82	9.74	13.99	8.11	8.51	4.54	2.81	4.93	2.98	2.99	6.55	8.77	5.73	3.35	7.69	3.97	87
(15) KA	6.54	9.47	5.95	2.24	4.93	4.68	6.26	3.23	4.66	5.03	2.44	3.18	2.76	54	3.03	5.29	6.32	10.61	4.68	5.17	1.25	296	2.00	489	356	3.43	5.61	2.44	0.32	4.49	2.45	1195
(16) NE	7.81	10.90	7.84	4.18	6.25	5.96	7.68	5.28	6.74	7.23	4.68	5.51	5.21	2.66	8.39	3.25	7.44	11.90	6.07	6.93	3.16	2.20	3.89	1.93	1.86	5.34	7.36	4.09	1.86	6.05	4.71	
(17) ND-SD	6.79	10.43	7.43	3.99	5.93	4.78	7.70	5.14	7.25	7.02	4.92	5.62	5.40	2.94	8.78	6.79	2.77	11.30	6.27	6.93	3.38	2.25	3.76	1.94	1.97	5.33	7.24	3.87	1.70	5.81	1.95	
(18) MN-WI	6.73	10.19	7.17	3.48	5.63	4.67	7.25	4.58	6.31	6.34	3.86	4.58	4.32	1.96	7.78	5.89	5.92	7.01	4.70	5.48	1.96	1.55	2.58	0.69	0.36	4.03	5.78	2.49	0.22	4.40	1.19	
(19) IA	6.79	9.93	6.82	3.12	5.33	4.78	6.88	4.23	5.89	6.00	3.39	4.08	3.77	1.38	7.15	5.39	6.39	10.10	1.47	5.00	1.38	0.68	2.32	0.33	0.12	3.63	5.53	2.24	354	4.23	1.41	354
(20) IL	10.81	13.92	10.71	6.86	9.37	8.85	10.79	7.94	9.66	9.81	7.15	7.65	7.52	5.16	11.03	9.72	10.47	14.23	8.35	5.38	4.82	3.81	5.65	3.57	3.07	6.74	8.58	5.45	3.30	7.52	4.64	
(21) MO	10.22	13.34	9.96	6.22	8.77	8.34	10.22	7.28	8.92	9.06	6.37	6.96	6.68	4.26	10.19	9.04	10.07	13.85	7.88	7.97	1.37	3.55	5.16	3.09	2.85	6.45	8.49	5.43	3.03	7.40	4.61	
(22) AR-LA	13.94	16.74	13.25	9.45	12.49	12.20	14.06	10.58	12.13	12.13	8.93	9.31	9.30	7.67	14.18	13.39	14.21	18.56	12.30	12.08	8.67	2.85	8.06	6.02	6.45	9.78	11.98	9.24	6.98	11.22	7.79	
(23) FL																							7.83								11.30	
(24) MS-AL-GA																							5.15	0.17	2.63	6.76	8.72	6.47	3.65	8.02	4.62	
(25) NC-SC																							10.49	9.03	3.95	12.67	13.05	11.92	8.87	12.71	9.01	
(26) KY-TN																							6.46	3.89	3.40	4.55	9.30	6.84	4.30	8.64	5.77	
(27) VA-WVA-MD-DE																							13.85	12.45	10.60	15.96	12.26	14.83	10.45	15.01	12.28	
(28) MI-IN-OH																							5.22	3.22	2.44	6.47	7.79	1.94	2.26	6.61	3.77	
(29) PA																							7.41	5.91	5.02	9.47	9.05	7.97	0.24	7.90	4.54	
(30) North East																														4.98	0.00	
Total						104								141								296		489	356				354		494	2234

*Underscored figures are shipments (in million pounds). Other figures are opportunity costs (in dollars per hundredweight) which result from not having an activity in the optimum solution.

Table 22. Model 4 - Optimum shipments of tray-ready beef and opportunity shipping costs,with short-run adjustments in merchandising costs, by region, 1988.

Originating	Destination Region*																													Total
Region/Area	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)	(13)	(14)	(15)	(16)	(17)	(18)	(19)	(20)	(21)	(22)	(23)	(24)	(25)	(26)	(27)	(28)	(29)	(30)	Shipped
(1) WA-OR	377	4.26	4.67	5.27	6.64																										377
(2) N.CA	5.76	1.07	4.73	5.82	7.84																										
(3) S.CA	6.03	4.58	0.51	4.65	7.44																										
(4) AZ	7.18	6.14	5.03	1.69	8.05																										
(5) UT-NV	2.73	2.41	2.15	2.31	0.13																										
(6) MT-ID-WY	1.88	2.44	2.38	2.52	3.33	0.73	6.51	3.38	7.15	6.01	5.81	3.96	4.15	4.45	7.19	6.54	6.16	6.27	5.71	3.34	3.14	3.82	2.96	3.02	2.99	3.15	3.35	2.62	2.72	2.90	
(7) CO	1.72	1.47	1.10	0.73	2.23	3.94	0.72	0.99	4.32	3.70	3.32	1.50	1.59	1.81	4.44	3.94	4.86	4.66	3.67	1.17	0.90	1.57	1.10	1.00	0.76	1.07	1.36	0.82	0.77	1.03	
(8) NM	6.63	5.90	5.12	4.65	7.08	8.95	9.12	1.88	8.61	7.46	7.55	5.83	5.97	6.30	9.32	9.50	10.25	9.83	8.86	6.18	5.83	6.02	5.55	5.59	5.49	5.79	6.18	5.73	5.80	5.98	
(9) TX-OK PAN.	2.70	2.04	1.31	0.89	3.29	4.93	4.79	0.96	0.79	3.51	2.80	1.04	0.99	1.26	4.40	4.58	5.94	5.19	4.18	1.54	1.15	1.26	0.92	0.91	0.72	1.13	1.43	1.16	0.97	1.29	
(10) W. TX	4.24	3.27	2.36	1.80	4.82	6.61	6.87	2.49	6.22	1.37	4.50	2.92	3.18	3.85	6.83	7.17	7.83	7.25	6.29	3.69	3.27	3.25	2.82	2.86	2.78	3.14	3.53	3.17	3.11	3.46	
(11) S.TX	6.28	5.54	4.77	4.30	6.93	8.60	8.77	4.89	7.86	6.83	1.71	2.98	3.75	4.82	8.03	8.37	9.46	8.52	7.47	4.82	4.39	3.97	3.66	3.73	3.50	4.09	4.41	4.26	4.18	4.48	
(12) SE.TX	8.88	8.26	7.51	7.07	9.57	11.18	11.39	7.60	10.55	9.67	7.42	2.25	6.13	7.27	10.51	10.93	11.90	10.99	9.91	7.11	6.77	6.15	5.87	5.94	5.79	6.39	6.54	6.60	6.29	6.65	
(13) E.TX	6.74	6.15	5.43	5.00	7.44	9.02	9.12	5.38	8.12	7.56	5.80	3.75	0.90	4.72	8.09	8.63	9.67	8.79	7.67	5.01	4.54	4.16	4.13	4.05	3.76	4.36	4.64	4.59	4.33	4.70	
(14) E.OK	6.43	5.90	5.21	4.77	7.08	8.65	8.67	5.04	7.70	7.53	6.19	4.19	4.03	1.30	7.28	8.03	9.17	8.43	7.29	4.66	4.13	4.40	4.14	4.03	3.74	4.22	4.52	4.28	3.96	4.43	
(15) KS	3.04	2.65	1.95	1.59	3.64	5.23	5.16	1.89	4.67	4.35	3.24	1.27	1.24	1.12	0.87	4.33	5.57	4.86	3.68	1.13	0.66	1.41	1.03	0.87	0.56	0.91	1.17	0.80	0.74	1.04	
(16) NE	3.60	3.39	3.14	2.83	4.27	5.82	5.88	3.24	6.05	5.84	4.78	2.90	2.98	3.08	5.53	1.58	5.98	5.45	4.37	2.20	1.86	2.90	2.22	2.10	1.72	2.12	2.22	1.75	1.59	1.91	
(17) ND-SD	2.69	3.03	2.84	2.74	4.05	4.74	6.01	3.21	6.67	5.73	5.12	3.12	3.27	3.47	6.03	5.23	1.42	4.96	4.68	2.30	2.19	3.06	2.19	2.22	1.94	2.22	2.20	1.64	1.54	1.77	
(18) MN-WI	3.26	3.41	3.20	2.86	4.38	5.26	6.19	3.28	6.36	5.69	4.70	2.71	2.82	3.11	5.65	4.96	5.20	1.30	3.74	1.48	1.40	2.99	1.64	1.60	0.95	1.54	1.38	0.88	0.68	0.99	
(19) IA	3.40	3.23	2.94	2.58	4.16	5.45	5.89	3.00	6.02	5.42	4.30	2.28	2.35	2.62	5.10	4.53	5.75	4.47	0.58	1.08	0.90	2.20	1.45	1.31	0.79	1.23	1.21	0.71	0.54	0.90	
(20) IL	7.20	7.00	6.61	6.10	7.98	9.30	9.59	6.51	9.57	9.02	7.85	5.64	5.89	6.18	8.76	8.65	9.61	8.38	7.25	1.24	4.12	5.12	4.57	4.34	3.53	4.13	4.04	3.71	3.62	3.98	
(21) MO	6.66	6.47	5.91	5.51	7.44	8.84	9.06	5.89	8.89	8.32	7.11	5.02	5.10	5.33	7.98	8.03	9.27	8.06	6.83	3.88	0.73	4.91	4.14	3.90	3.36	3.88	4.00	3.74	3.41	3.90	
(22) AR-LA	9.83	9.32	8.65	8.19	10.60	12.15	12.36	8.64	11.54	10.83	9.12	6.80	7.17	8.18	11.42	11.81	12.85	12.21	10.69	7.44	7.47	3.65	6.49	6.28	6.41	6.65	6.93	6.99	6.80	7.17	
(23) FL																							5.58								
(24) MS-AL-GA																							3.93	0.78	2.94	3.99	4.02	4.58	3.83	4.32	
(25) NC-SC																							8.79	9.18	3.79	9.44	7.89	9.56	8.58	8.54	
(26) KY-TN																							5.24	4.52	3.72	1.79	4.62	4.96	4.49	4.95	
(27) VA-WVA-MD-DE																							11.49	11.94	9.78	12.06	6.44	11.81	9.49	10.18	
(28) MI-IN-OH																							4.47	4.32	3.23	4.18	3.57	0.52	2.91	3.39	
(29) PA																							6.37	6.72	5.52	6.89	4.55	6.26	0.60	4.40	
(30) North East																														1.64	
Total	377																														377

*Underscored figures are shipments (in million pounds). Other figures are opportunity costs (in dollars per hundredweight) which result from not having an activity in the optimum solution.

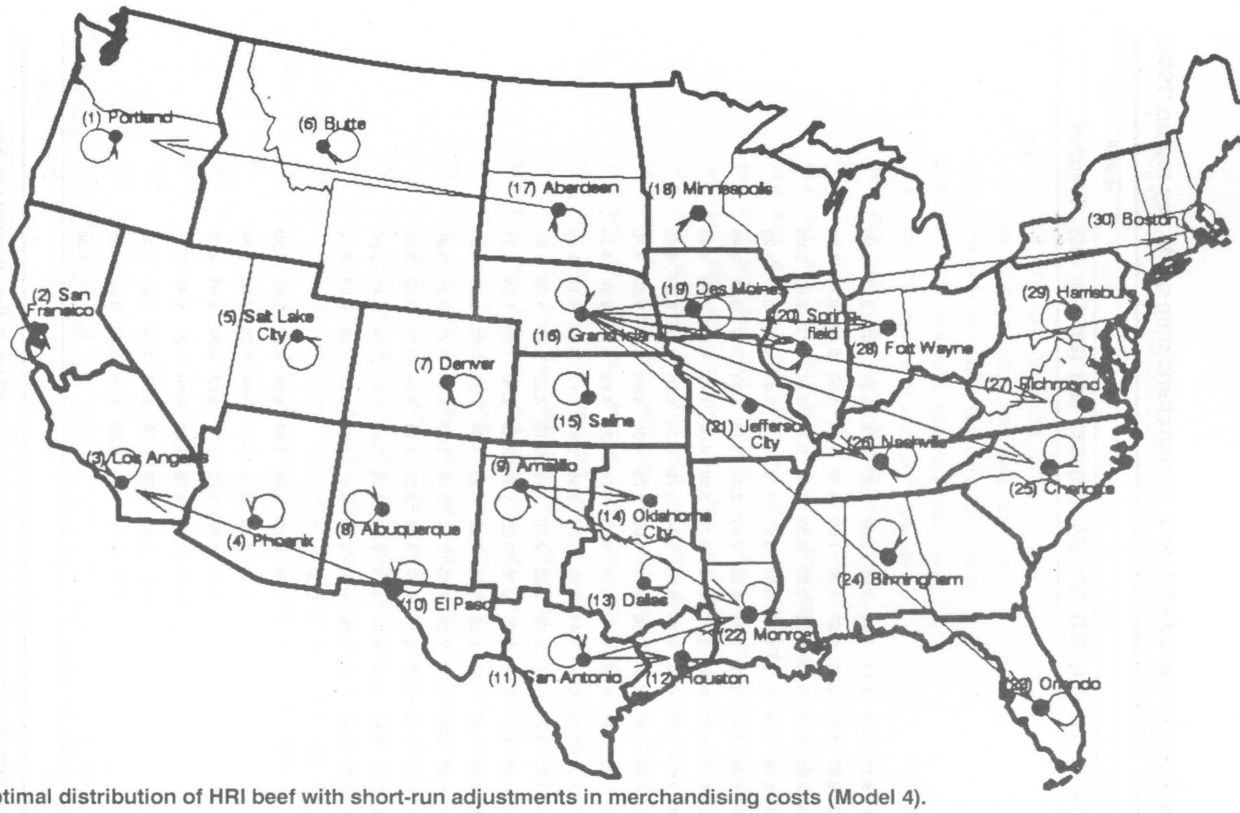

Figure 9. Optimal distribution of HRI beef with short-run adjustments in merchandising costs (Model 4).

Packaging/Distribution Systems

Model 5 was designed to measure the impact of intermediate-run adjustments on alternative packaging/distribution systems. This model analyzed the impact of a $6.00/hundredweight decrease in marketing and distribution costs, compared with initial start-up costs, as a result of industry adjustments and consumer acceptance of case-ready-beef packaging systems. Although precise data on costs associated with industry adoption of case-ready beef are not available, industry personnel suggested that costs associated with promotions, advertising, and labor would likely decline, compared with initial start-up costs, as a result of industry adjustments and consumer acceptance of case-ready-beef packaging systems. Model 5 was designed to measure the impact of a $6.00/hundredweight decrease in costs compared with initial start-up costs.

Model 6, on the other hand, reflects the impact of long run adjustments on alternative packaging/distribution systems if variable and fixed costs were decreased by a minimum of $9.00/hundredweight compared with initial start-up costs as shown in Model 3. In Model 6, all retail wage costs for case-ready systems were reduced to 75 percent of the previous models to reflect retailers adjusting to fewer skilled employees in the meat department. This applies to the remaining models.

The VAL-ADD simulation model revealed that decreasing merchandising costs from $6.00 to $9.00/hundredweight would have no impact on regional distribution patterns by alternative packaging/distribution systems other than the higher total packaging/distribution costs associated with Model 5 compared with Model 6. In other words, optimal packaging/distribution systems and optimal regional beef distribution patterns by packaging/distribution system were identical in Models 5 and 6. While some adjustments in shipment patterns may occur in the industry as costs decrease from $6.00 to $9.00/hundredweight, the VAL-ADD model revealed that regional shipment patterns, under the conditions assumed in Models 5 and 6, would not undergo any changes as a result of a 3-cent-per-pound change in cost.

More than 97 percent of the non-HRI domestic beef was shipped as central vacuum packaged beef under the scenario assumed in Models 5 and 6, Table 24. Tray-ready beef accounted for the remaining non-HRI domestic beef shipments. These models suggest that central vacuum packaging/distribution would be the dominant beef packaging/distribution system for non-HRI domestic beef given long-run consumer acceptance of vacuum-packaged, case-ready beef along with retailer adjustments in variable and fixed costs, reflecting full adoption of case-ready beef. These results imply that technological developments for vacuum-packaged beef may be able to overcome lack of acceptable color, currently associated with vacuum-packaged beef by many consumers, by supplying the product at a lower cost.

Table 23. Model 4 - Optimum shipments of HRI beef and opportunity shipping costs,with short-run adjustments in merchandising costs, by region, 1988.

Originating	Destination Region*																													Total
Region/Area	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)	(13)	(14)	(15)	(16)	(17)	(18)	(19)	(20)	(21)	(22)	(23)	(24)	(25)	(26)	(27)	(28)	(29)	(30)	Shipped
(1) WA-OR	135	6.15	6.93	10.52	8.92																										135
(2) N.CA	5.49	243	4.76	9.08	8.46																										243
(3) S.CA	6.53	5.03	24	7.99	8.52																										24
(4) AZ	3.77	2.87	1.38	72	4.96																										72
(5) UT-NV	3.11	3.29	3.07	6.00	56																										56
(6) MT-ID-WY	1.05	2.55	2.63	5.52	3.10	45	7.62	6.39	9.24	8.63	9.91	6.17	6.11	5.42	8.75	9.39	8.46	6.78	6.77	4.61	4.80	4.48	4.01	5.41	4.79	4.43	4.59	4.19	5.54	4.37	45
(7) CO	0.93	1.23	0.83	2.97	1.57	4.00	76	2.92	5.12	5.28	6.30	2.61	2.39	1.57	4.74	5.61	6.62	4.49	3.84	1.47	1.57	1.23	1.33	2.50	1.56	1.43	1.72	1.62	2.74	1.69	76
(8) NM	3.11	2.68	1.67	3.66	3.65	6.33	6.47	28	6.37	5.73	7.45	3.91	3.78	3.12	6.88	8.76	9.53	7.06	6.43	3.80	3.77	2.71	2.82	4.19	3.49	3.32	3.78	3.79	5.09	3.93	28
(9) TX-OK PAN.	1.66	1.32	0.40	2.45	2.40	4.73	4.40	2.13	37	4.25	4.76	1.17	0.74	61	3.92	5.81	7.49	4.53	3.85	1.27	1.19	15	0.31	1.60	0.75	0.76	1.08	1.37	2.27	1.33	113
(10) W. TX	2.00	1.20	448	1.86	2.73	5.29	5.56	2.45	5.25	18	5.35	2.02	2.06	1.91	5.61	7.73	8.37	5.66	5.05	2.54	2.40	1.02	1.19	2.58	1.89	1.82	2.27	2.42	3.52	2.62	466
(11) S.TX	2.96	2.51	1.51	3.51	3.80	6.17	6.31	3.95	5.61	5.16	80	81	0.81	1.27	5.31	7.43	8.70	5.47	4.71	2.13	1.99	61	0.35	1.78	0.86	1.14	1.49	1.96	3.03	2.04	222
(12) SE.TX	7.04	6.76	5.80	7.83	7.93	10.22	10.41	8.19	9.82	9.59	7.81	21	4.56	5.12	9.20	11.46	12.54	9.33	8.55	5.73	5.72	3.44	3.84	5.26	4.46	4.76	4.85	5.64	6.37	5.47	21
(13) E.TX	6.18	5.96	5.05	7.08	7.10	9.33	9.37	7.23	8.53	8.80	7.74	3.70	133	3.65	7.93	10.36	11.56	8.39	7.55	4.95	4.74	2.82	3.59	4.80	3.79	4.07	4.36	4.99	5.79	4.91	133
(14) E.OK	6.66	6.52	5.64	7.68	7.50	9.72	9.63	7.65	8.84	9.69	9.26	5.30	4.70	0.40	7.66	10.41	11.75	8.80	7.92	5.36	5.07	4.13	4.55	5.71	4.70	4.80	5.12	5.45	6.17	5.45	
(15) KS	2.59	2.68	1.79	3.93	3.37	5.62	5.40	3.95	5.32	5.93	5.86	1.95	1.54	0.22	56	5.87	7.37	4.47	3.53	1.09	0.88	0.66	0.90	1.98	0.95	0.87	1.13	1.27	2.37	1.39	56
(16) NE	0.75	1.09	0.88	3.10	1.61	3.81	3.79	3.28	4.71	5.49	5.48	1.70	1.47	0.46	3.37	36	5.30	2.66	1.88	231	113	0.21	165	1.14	61	18	207	557	0.94	700	2088
(17) ND-SD	27	1.16	1.05	3.58	1.90	2.80	4.59	3.85	6.24	5.94	6.60	2.64	2.52	1.66	4.72	5.15	29	2.53	2.95	0.76	1.10	1.06	0.57	1.92	0.94	0.76	0.59	0.45	1.48	0.40	56
(18) MN-WI	2.89	3.78	3.62	5.79	4.43	5.62	6.89	5.99	7.81	7.90	8.00	4.06	3.88	3.16	6.19	6.77	6.78	207	3.57	1.57	1.95	2.99	1.79	3.03	1.50	1.78	1.39	1.35	2.23	1.27	207
(19) IA	3.33	3.73	3.46	5.61	4.33	6.13	6.68	5.81	7.54	7.74	7.64	3.66	3.41	2.65	5.60	6.37	7.83	4.07	62	1.21	1.44	2.04	1.74	2.84	1.49	1.53	1.37	1.32	2.26	1.37	62
(20) IL	6.67	7.02	6.59	8.53	7.70	9.54	9.86	8.69	10.50	10.76	10.59	6.32	6.34	5.63	8.73	10.18	11.26	7.57	6.71	50	3.90	4.05	4.04	5.01	3.23	3.51	3.25	3.45	4.51	3.61	50
(21) MO	6.19	6.57	5.89	7.96	7.22	9.20	9.42	8.11	9.81	10.06	9.84	5.73	5.50	4.70	7.90	9.59	11.08	7.43	6.42	3.38	0.08	4.07	3.73	4.70	3.31	3.49	3.53	3.85	4.54	3.84	
(22) AR-LA	7.82	7.72	6.88	8.88	8.84	11.04	11.24	9.12	10.67	10.71	9.73	5.28	5.48	5.86	9.93	12.15	13.33	10.54	9.09	5.60	6.14	51	4.13	5.15	4.76	4.52	4.81	5.60	6.50	5.62	51
(23) FL																							104								104
(24) MS-AL-GA																							2.47	241	1.73	2.70	2.62	4.14	4.21	3.52	241
(25) NC-SC																							5.83	7.73	127	6.93	4.48	7.68	7.40	5.92	127
(26) KY-TN																							4.11	4.33	2.58	149	3.19	4.39	4.87	4.14	149
(27) VA-WVA-MD-DE																							6.65	8.64	4.84	7.66	73	7.83	5.55	5.15	73
(28) MI-IN-OH																							4.93	6.01	3.81	4.63	3.59	0.63	4.48	3.76	
(29) PA																							5.84	7.67	5.31	6.75	3.10	6.38	269	3.34	269
(30) North East																														255	255
Total	162	243	472	72	56	45	76	28	37	18	80	102	133	61	56	36	29	207	62	281	113	127	269	241	188	167	280	557	269	955	5422

*Underscored figures are shipments (in million pounds). Other figures are opportunity costs (in dollars per hundredweight) which result from not having an activity in the optimum solution.

Table 24. Models 5 and 6 - Optimum shipments of beef, with intermediate- and long-run adjustments in merchandising costs, by beef packaging/distribution system, 1988.

Packaging/distribution system	Beef shipped (million pounds)
Boxed beef:	
Domestic market	0
Export market	494
Tray-ready	377
Central vacuum	12,272
HRI	5,422
Total shipped	18,565

Central Vacuum. More than two-thirds of the central vacuum beef was distributed on an interregional basis under full adoption and long-run adjustments in costs, Figure 10 and Table 25. Major out-of-state suppliers of central-vacuum beef were Kansas, Texas-Oklahoma Panhandle, Colorado, Nebraska, and Iowa.

Kansas had a competitive advantage for the central-vacuum beef market in the Atlantic Coast and southeastern states where it competed with the Texas-Oklahoma Panhandle for the Florida market. Kansas also competed for the deficit Northeast with Nebraska, Iowa, Minnesota-Wisconsin, and North Dakota-South Dakota, which shipped surplus beef to the deficit Northeast. The exception to this shipment pattern was Iowa, which also shipped central vacuum beef to Pennsylvania.

Texas-Oklahoma Panhandle had a competitive advantage in shipping central-vacuum beef to the nearby southeastern states, including Southern California where it competed for that market with Colorado, Figure 10 and Table 25. The largest out-of-state markets for Texas-Oklahoma Panhandle were Florida and Southern California.

Colorado shipped all of its surplus central-vacuum beef to the West Coast. Northern California and Southern California received almost equal amounts of the Colorado surplus central-vacuum beef.

Tray-ready. Approximately 3 percent of the non-HRI domestic beef was packaged/distributed as tray-ready beef by Washington-Oregon for sale within its own region, Figure 10 and Table 26. Packer labor costs were substantially higher in Washington-Oregon (Table 1), thereby encouraging intraregional shipments of tray-ready beef since tray-ready beef is less labor intensive than central-vacuum beef. Opportunity costs (non-underlined figures) of less than $1.00 per hundredweight in Table 26 for the Texas-Oklahoma Panhandle, Kansas, and Iowa suggests that these regions have numerous potential markets for tray-ready beef. Since tray-ready beef has the same

Figure 10. Optimal distribution of vacuum packaged, tray-ready, and boxed beef exports with intermediate- and long-run adjustments in merchandising costs (Models 5 and 6).

Table 25. Models 5 and 6 - Optimum shipments of central vacuum beef and opportunity shipping costs, with intermediate-run and long-run adjustments in merchandising costs, by region, 1988.

Originating	Destination Region*																													Total
Region/Area	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)	(13)	(14)	(15)	(16)	(17)	(18)	(19)	(20)	(21)	(22)	(23)	(24)	(25)	(26)	(27)	(28)	(29)	(30)	Shipped
(1) WA-OR	0.00	3.60	4.38	5.42	6.71																										
(2) N.CA	5.36	150	4.03	5.55	7.50																										150
(3) S.CA	5.82	3.71	238	4.58	7.29																										238
(4) AZ	5.34	3.63	2.90	154	6.26																										154
(5) UT-NV	2.53	1.55	1.67	2.26	130																										130
(6) MT-ID-WY	1.27	1.17	1.48	2.05	2.79	104	6.00	2.84	6.78	5.55	5.64	3.34	3.58	3.85	6.85	6.35	6.00	5.45	5.52	2.75	3.00	2.99	2.47	2.68	2.95	2.76	2.71	2.34	2.57	2.38	104
(7) CO	0.91	418	467	0.06	1.48	3.01	177	0.23	3.75	3.03	2.95	0.68	0.81	1.00	3.89	3.55	4.49	3.64	3.28	0.37	0.56	0.53	0.39	0.45	0.51	0.48	0.51	0.34	0.42	0.31	1062
(8) NM	4.69	3.30	2.89	2.85	5.20	6.89	7.27	38	6.91	5.66	6.05	3.87	4.07	4.36	7.64	7.96	8.76	7.68	7.33	4.25	4.36	3.85	3.72	3.91	4.12	4.07	4.20	4.12	4.31	4.13	38
(9) TX-OK PAN.	1.68	0.35	395	14	2.32	3.78	3.85	27	87	2.63	2.21	236	223	0.24	3.63	3.97	5.36	3.95	3.57	0.53	0.60	296	624	0.14	0.26	0.32	0.37	0.46	0.39	0.36	1902
(10) W. TX	2.73	1.09	0.56	0.43	3.37	4.96	5.45	1.04	4.95	43	3.43	1.39	1.71	2.34	5.58	6.08	6.77	5.53	5.20	2.20	2.23	1.51	1.42	1.61	1.84	1.85	1.98	1.99	2.05	2.05	43
(11) S.TX	4.13	2.72	2.32	2.29	4.84	6.32	6.70	2.79	5.95	4.82	187	0.81	1.62	2.67	6.14	6.63	7.75	6.16	5.73	2.68	2.71	1.58	1.61	1.83	1.91	2.15	2.22	2.43	2.48	2.41	187
(12) SE.TX	7.29	6.00	5.62	5.61	8.03	9.46	9.88	6.06	9.19	8.21	6.26	0.63	4.57	5.67	9.17	9.75	10.75	9.17	8.72	5.52	5.63	4.32	4.37	4.60	4.76	5.00	4.90	5.33	5.14	5.14	
(13) E.TX	5.81	4.55	4.21	4.20	6.57	7.96	8.27	4.51	7.42	6.77	5.31	2.80	89	3.79	7.41	8.11	9.18	7.64	7.15	4.09	4.07	3.00	3.30	3.38	3.40	3.63	3.66	3.98	3.85	3.85	89
(14) E.OK	5.12	3.93	3.60	3.60	5.83	7.21	7.45	3.78	6.62	6.36	5.32	2.87	2.75	26	6.23	7.14	8.31	6.90	6.40	3.36	3.29	2.86	2.94	2.98	3.00	3.12	3.16	3.29	3.10	3.21	26
(15) KS	1.91	0.86	0.53	0.60	2.58	3.96	4.12	0.82	3.78	3.36	2.55	0.13	0.14	115	130	3.62	4.89	3.52	2.96	0.01	56	0.05	3	489	439	390	653	739	0.07	219	3233
(16) NE	1.61	0.72	0.85	0.97	2.33	3.69	3.97	1.29	4.29	3.99	3.22	0.88	1.01	1.08	3.79	83	4.43	3.24	2.79	0.21	0.33	0.67	0.32	0.36	0.29	0.34	0.18	0.08	0.04	866	949
(17) ND-SD	0.83	0.50	0.68	1.02	2.25	2.75	4.23	1.40	5.04	4.01	3.69	1.24	1.44	1.60	4.42	3.79	67	2.88	3.23	0.44	0.79	0.97	0.43	0.61	0.64	0.57	0.30	0.10	0.12	132	199
(18) MN-WI	2.18	1.66	1.82	1.91	3.36	4.05	5.19	2.25	5.51	4.74	4.05	1.60	1.77	2.03	4.82	4.29	4.56	483	3.07	0.41	0.78	1.68	0.66	0.77	0.44	0.67	0.25	0.13	0.05	572	1055
(19) IA	2.41	1.57	1.65	1.73	3.23	4.33	4.99	2.07	5.26	4.58	3.75	1.28	1.40	1.63	4.37	3.96	5.20	3.26	145	0.10	0.37	0.96	0.57	0.58	0.37	0.45	0.17	0.05	354	440	939
(20) IL	5.95	5.09	5.06	4.99	6.79	7.92	8.42	5.31	8.56	7.91	7.03	4.37	4.67	4.93	7.77	7.81	8.81	6.91	6.41	656	3.34	3.64	3.43	3.35	2.85	3.09	2.75	2.79	2.82	2.81	656
(21) MO	5.47	4.62	4.43	4.46	6.31	7.53	7.96	4.75	7.93	7.27	6.36	3.81	3.94	4.14	7.05	7.25	8.52	6.65	6.05	2.70	208	3.48	3.05	2.97	2.73	2.91	2.76	2.88	2.67	2.80	208
(22) AR-LA	8.16	6.99	6.69	6.66	8.99	10.36	10.78	7.03	10.11	9.31	7.89	5.11	5.53	6.52	10.01	10.56	11.62	10.33	9.44	5.78	6.27	1.75	4.92	4.87	5.30	5.20	5.22	5.65	5.58	5.59	
(23) FL																							2.98								
(24) MS-AL-GA																							2.99	74	2.46	3.16	2.94	3.86	3.23	3.37	74
(25) NC-SC																							6.88	7.42	2.33	7.62	5.83	7.87	7.00	6.61	
(26) KY-TN																							3.92	3.35	2.87	0.58	3.16	3.86	3.51	3.62	
(27) VA-WVA-MD-DE																							8.75	9.35	7.50	9.43	3.55	9.29	7.10	7.42	
(28) MI-IN-OH																							3.73	3.72	2.94	3.54	2.68	562	2.51	2.62	562
(29) PA																							5.42	5.92	5.03	6.04	3.45	5.54	274	3.43	274
(30) North East																														0.73	
Total		568	1100	168	130	104	177	65	87	43	187	236	312	141	130	83	67	483	145	656	264	296	627	563	439	390	653	1301	628	2229	12272

*Underscored figures are shipments (in million pounds). Other figures are opportunity costs (in dollars per hundredweight) which result from not having an activity in the optimum solution.

Table 26. Models 5 and 6 - Optimum shipments of tray-ready beef and opportunity shipping costs, with intermediate-run and long-run adjustments in merchandising costs, by region, 1988.

Originating	Destination Region*																													Total
Region/Area	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)	(13)	(14)	(15)	(16)	(17)	(18)	(19)	(20)	(21)	(22)	(23)	(24)	(25)	(26)	(27)	(28)	(29)	(30)	Shipped
(1) WA-OR	377	4.03	4.44	5.04	6.41																										377
(2) N.CA	5.99	1.07	4.73	5.82	7.84																										
(3) S.CA	6.26	4.58	0.51	4.65	7.44																										
(4) AZ	7.41	6.14	5.03	1.69	8.05																										
(5) UT-NV	2.96	2.41	2.15	2.31	0.13																										
(6) MT-ID-WY	2.11	2.44	2.38	2.52	3.33	0.30	6.51	3.38	7.15	6.01	5.91	3.96	4.15	4.07	7.50	6.85	6.47	6.58	6.02	3.65	3.45	3.17	2.96	2.93	3.25	3.46	3.66	2.93	2.88	3.21	
(7) CO	1.95	1.47	1.10	0.73	2.23	3.51	0.72	0.99	4.32	3.70	3.42	1.50	1.59	1.43	4.75	4.25	5.17	4.97	3.98	1.48	1.21	0.92	1.10	0.91	1.02	1.38	1.67	1.13	0.93	1.34	
(8) NM	6.86	5.90	5.12	4.65	7.08	8.52	9.12	1.88	8.61	7.46	7.65	5.83	5.97	5.92	9.63	9.81	10.56	10.14	9.17	6.49	6.14	5.37	5.55	5.50	5.75	6.10	6.49	6.04	5.96	6.29	
(9) TX-OK PAN.	2.93	2.04	1.31	0.89	3.29	4.50	4.79	0.96	0.79	3.51	2.90	1.04	0.99	0.88	4.71	4.89	6.25	5.50	4.49	1.85	1.46	0.61	0.92	0.82	0.98	1.44	1.74	1.47	1.13	1.60	
(10) W. TX	4.47	3.27	2.36	1.80	4.82	6.18	6.87	2.49	6.22	1.37	4.60	2.92	3.18	3.47	7.14	7.48	8.14	7.56	6.60	4.00	3.58	2.60	2.82	2.77	3.04	3.45	3.84	3.48	3.27	3.77	
(11) S.TX	6.41	5.44	4.67	4.20	6.83	8.07	8.67	4.79	7.76	6.73	1.71	2.88	3.65	4.34	8.24	8.58	9.67	8.73	7.68	5.03	4.60	3.22	3.56	3.54	3.66	4.30	4.62	4.47	4.24	4.69	
(12) SE.TX	9.01	8.16	7.41	6.97	9.47	10.65	11.29	7.50	10.45	9.57	7.42	2.15	6.03	6.79	10.72	11.14	12.11	11.20	10.12	7.32	6.98	5.40	5.77	5.75	5.95	6.60	6.75	6.81	6.35	6.86	
(13) E.TX	6.97	6.15	5.43	5.00	7.44	8.59	9.12	5.38	8.12	7.56	5.90	3.75	0.90	4.34	8.40	8.94	9.96	9.10	7.98	5.32	4.85	3.51	4.13	3.96	4.02	4.67	4.95	4.90	4.49	5.01	
(14) E.OK	5.94	5.18	4.49	4.05	6.36	7.50	7.95	4.32	6.98	6.81	5.57	3.47	3.31	0.20	6.87	7.62	8.76	8.02	6.88	4.25	3.72	3.03	3.42	3.22	3.28	3.81	4.11	3.87	3.40	4.02	
(15) KS	2.96	2.34	1.64	1.28	3.33	4.49	4.85	1.58	4.36	4.04	3.03	0.96	0.93	0.43	0.87	4.33	5.57	4.86	3.68	1.13	0.66	0.45	0.72	0.47	0.51	0.91	1.17	0.80	0.59	1.04	
(16) NE	3.52	3.08	2.83	2.52	3.96	5.08	5.57	2.93	5.74	5.53	4.57	2.59	2.67	2.39	5.53	1.58	5.98	5.45	4.37	2.20	1.86	1.94	1.91	1.70	1.67	2.12	2.22	1.75	1.44	1.91	
(17) ND-SD	2.61	2.72	2.53	2.43	3.74	4.00	5.70	2.90	6.36	5.42	4.91	2.81	2.96	2.78	6.03	5.25	1.42	4.96	4.68	2.30	2.19	2.10	1.88	1.82	1.89	2.22	2.20	1.64	1.39	1.77	
(18) MN-WI	3.18	3.10	2.89	2.55	4.07	4.52	5.88	2.97	6.05	5.38	4.49	2.40	2.51	2.42	5.65	4.96	5.20	1.30	3.74	1.48	1.40	2.03	1.33	1.20	0.90	1.54	1.38	0.88	0.53	0.99	
(19) IA	3.32	2.92	2.63	2.27	3.85	4.71	5.58	2.69	5.71	5.11	4.09	1.97	2.04	1.93	5.10	4.53	5.75	4.47	0.58	1.08	0.90	1.24	1.14	0.91	0.74	1.23	1.21	0.71	0.39	0.90	
(20) IL	7.12	6.69	6.30	5.79	7.67	8.56	9.28	6.20	9.26	8.71	7.64	5.33	5.58	5.49	8.76	8.65	9.61	8.38	7.25	1.24	4.12	4.16	4.26	3.94	3.48	4.13	4.04	3.71	3.47	3.98	
(21) MO	6.58	6.16	5.60	5.20	7.13	8.10	8.75	5.58	8.58	8.01	6.90	4.71	4.79	4.64	7.96	8.03	9.27	8.06	6.83	3.88	0.73	3.95	3.83	3.50	3.31	3.88	4.00	3.74	3.26	3.90	
(22) AR-LA	9.96	9.22	8.55	8.09	10.50	11.62	12.26	8.54	11.44	10.73	9.12	6.70	7.07	7.70	11.63	12.02	13.06	12.42	10.90	7.65	7.68	2.90	6.39	6.09	6.57	6.86	7.14	7.20	6.86	7.38	
(23) FL																							5.27								
(24) MS-AL-GA																							4.02	0.78	3.29	4.39	4.42	4.98	4.08	4.72	
(25) NC-SC																							8.48	8.78	3.74	9.44	7.89	9.56	8.43	8.54	
(26) KY-TN																							4.93	4.12	3.67	1.79	4.62	4.96	4.34	4.95	
(27) VA-WVA-MD-DE																							11.18	11.54	9.73	12.06	6.44	11.81	9.34	10.18	
(28) MI-IN-OH																							4.16	3.92	3.18	4.18	3.57	0.52	2.76	3.39	
(29) PA																							6.21	6.47	5.62	7.04	4.70	6.41	0.60	4.55	
(30) North East																														1.64	
Total	377																														377

*Underscored figures are shipments (in million pounds). Other figures are opportunity costs (in dollars per hundredweight) which result from not having an activity in the optimum solution.

appearance as store-cut packages, this may be the most profitable alternative in the transition to case-ready beef.

Boxed Beef. All of the boxed beef, as in most previous models, was destined for the export market, Figure 10. Regions shipping boxed beef to the export market included Colorado, Utah-Nevada, Washington-Oregon, and Montana-Idaho-Wyoming.

HRI. Costs were minimized in Models 5 and 6 when 48 percent of HRI beef was merchandised on an intraregional basis, Figure 11 and Table 27. Further, costs were minimized when surplus beef producing regions such as Texas-Oklahoma Panhandle, Kansas, Colorado, and Iowa shipped their surplus beef to other regions as central-vacuum rather than HRI-packaged beef.

Regions shipping surplus beef as HRI-packaged beef included Nebraska, North Dakota-South Dakota, West Texas, and South Texas. These four surplus beef regions had a common thread—lower reported packer wage rates compared with other surplus beef regions, Table 1.

The major out-of-state supplier of HRI-packaged beef was Nebraska, which provided all of the HRI beef shipments to the Northeast, nearby mid-West regions, Atlantic Coast, and Southeastern states, Figure 11. South Texas shipped HRI beef to East Texas and Arkansas-Louisiana.

West Texas shipped its surplus HRI beef to Southern California. All of the HRI beef requirements for Washington-Oregon were shipped into that region by North Dakota-South Dakota.

Impact of Regional Shifts in Population and Fed-beef Production on Alternative Packaging/ Distribution Systems

In addition to the basic cost factors that impact alternative packaging/distribution systems, external factors such as regional shifts in population and fed-beef production, also have the potential to affect alternative packaging/distribution systems.

Impact of Regional Shifts in Population

Model 7 revealed that regional shifts in beef demand, as reflected by regional projections in population shifts by U.S. Department of Commerce for year 2000, had little or no impact on the longer run adoption of alternative packaging/ distri bution systems as shown in Model 6. Model 7 estimated that costs would be minimized when all of the non-HRI domestic beef would be merchandised as central-vacuum beef, Figure 12. Model 6 previously showed that total costs would be minimized under the basic longer run scenario when more than 97 percent of the non-HRI domestic beef was merchandised as central-vacuum beef.

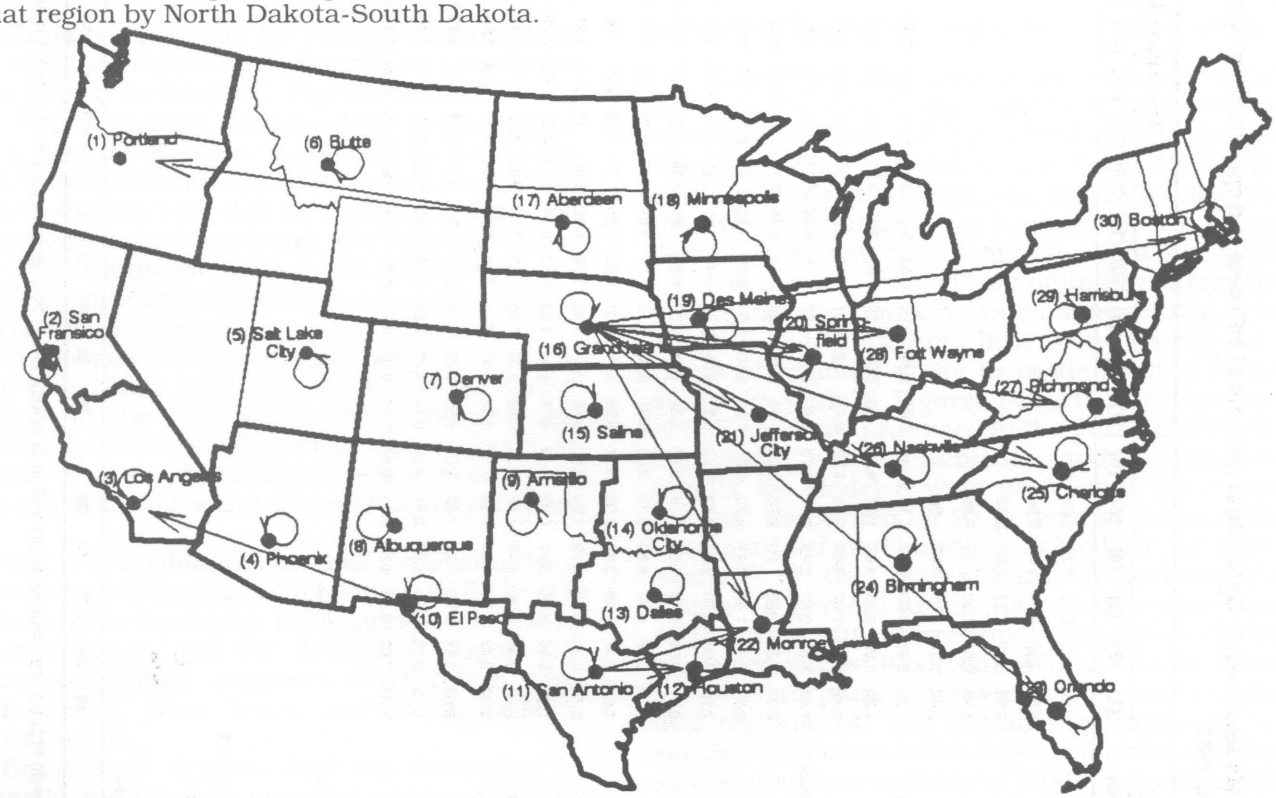

Figure 11. Optimal distribution of HRI beef with intermediate-run and long-run adjustments in merchandising costs (Models 5 and 6).

Table 27. Models 5 and 6 - Optimum shipments of HRI beef and opportunity shipping costs, with intermediate- and long-run adjustments in merchandising costs, by region, 1988.

Originating	Destination Region*																													Total
Region/Area	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)	(13)	(14)	(15)	(16)	(17)	(18)	(19)	(20)	(21)	(22)	(23)	(24)	(25)	(26)	(27)	(28)	(29)	(30)	Shipped
(1) WA-OR	0.08	5.92	6.70	10.29	8.69																										
(2) N.CA	5.80	243	4.76	9.08	8.46																										243
(3) S.CA	6.84	5.03	24	7.99	8.52																										24
(4) AZ	4.08	2.87	1.38	72	4.96																										72
(5) UT-NV	3.42	3.29	3.07	6.00	56																										56
(6) MT-ID-WY	1.36	2.55	2.63	5.52	3.10	45	7.62	6.39	9.24	8.63	10.01	6.27	6.11	5.74	9.06	9.70	8.77	7.09	7.08	4.92	5.11	4.58	4.32	5.32	5.10	4.74	4.90	4.50	5.70	4.68	45
(7) CO	1.24	1.23	0.83	2.97	1.57	4.00	76	2.92	5.12	5.28	6.40	2.71	2.39	1.89	5.05	5.92	6.93	4.80	4.15	1.78	1.88	1.33	1.64	2.41	1.87	1.74	2.03	1.93	2.90	2.00	76
(8) NM	3.42	2.68	1.67	3.66	3.65	6.33	6.47	28	6.37	5.73	7.55	4.01	3.78	3.44	7.19	9.07	9.84	7.37	6.74	4.11	4.08	2.81	3.13	4.10	3.80	3.63	4.09	4.10	5.25	4.24	28
(9) TX-OK PAN.	1.97	1.32	0.40	2.45	2.40	4.73	4.40	2.13	37	4.25	4.86	1.27	0.74	0.32	4.23	6.12	7.80	4.84	4.16	1.58	1.50	0.10	0.62	1.51	1.06	1.07	1.39	1.68	2.43	1.64	37
(10) W. TX	2.31	1.20	448	1.86	2.73	5.29	5.56	2.45	5.25	18	5.45	2.12	2.06	2.23	5.92	8.04	8.68	5.97	5.36	2.85	2.71	1.12	1.50	2.49	2.20	2.13	2.58	2.73	3.68	2.93	466
(11) S.TX	3.17	2.41	1.41	3.41	3.70	6.07	6.21	3.85	5.51	5.06	80	81	0.71	1.49	5.52	7.64	8.91	5.68	4.92	2.34	2.20	61	0.56	1.59	1.07	1.35	1.70	2.17	3.09	2.25	222
(12) SE.TX	7.25	6.66	5.70	7.73	7.83	10.12	10.31	8.09	9.72	9.49	7.81	21	4.46	5.34	9.41	11.67	12.75	9.54	8.76	5.94	5.93	3.44	4.05	5.07	4.67	4.97	5.06	5.85	6.43	5.68	21
(13) E.TX	6.49	5.96	5.05	7.08	7.10	9.33	9.37	7.23	8.53	8.80	7.84	3.80	133	3.97	8.24	10.67	11.87	8.70	7.86	5.26	5.05	2.92	3.90	4.71	4.10	4.38	4.67	5.30	5.95	5.22	133
(14) E.OK	6.25	5.80	4.92	6.96	6.78	9.00	8.91	6.93	8.12	8.97	8.64	4.68	3.96	61	7.25	10.00	11.34	8.39	7.51	4.95	4.66	3.51	4.14	4.90	4.29	4.39	4.71	5.04	5.61	5.04	61
(15) KS	2.59	2.37	1.48	3.62	3.06	5.31	5.09	3.64	5.01	5.62	5.65	1.74	1.23	0.23	56	5.87	7.37	4.47	3.53	1.09	0.88	0.45	0.90	1.58	0.95	0.87	1.13	1.27	2.22	1.39	56
(16) NE	0.75	0.78	0.57	2.79	1.30	3.50	3.48	2.97	4.40	5.18	5.27	1.49	1.16	0.47	3.37	36	5.30	2.66	1.88	231	113	15	165	0.74	61	18	207	557	0.79	700	2103
(17) ND-SD	162	0.85	0.74	3.27	1.59	2.49	4.28	3.54	5.93	5.63	6.39	2.43	2.21	1.67	4.72	5.15	29	2.53	2.95	0.76	1.10	0.85	0.57	1.52	0.94	0.76	0.59	0.45	1.33	0.40	191
(18) MN-WI	2.89	3.47	3.31	5.48	4.12	5.31	6.58	5.68	7.50	7.59	7.79	3.85	3.57	3.17	6.19	6.77	6.78	207	3.57	1.57	1.95	2.78	1.79	2.63	1.50	1.78	1.39	1.35	2.08	1.27	207
(19) IA	3.33	3.42	3.15	5.30	4.02	5.82	6.37	5.50	7.23	7.43	7.43	3.45	3.10	2.66	5.60	6.37	7.83	4.07	62	1.21	1.44	1.83	1.74	2.44	1.49	1.53	1.37	1.32	2.11	1.37	62
(20) IL	6.67	6.71	6.28	8.22	7.39	9.23	9.55	8.38	10.19	10.45	10.38	6.11	6.03	5.64	8.73	10.18	11.26	7.57	6.71	50	3.90	3.84	4.04	4.61	3.23	3.51	3.25	3.45	4.36	3.61	50
(21) MO	6.19	6.26	5.58	7.67	6.91	8.89	9.11	7.80	9.50	9.75	9.63	5.52	5.19	4.71	7.90	9.59	11.08	7.43	6.42	3.38	0.08	3.86	3.73	4.30	3.31	3.49	3.53	3.85	4.39	3.84	
(22) AR-LA	8.03	7.62	6.78	8.78	8.74	10.94	11.14	9.02	10.57	10.61	9.73	5.28	5.38	6.08	10.14	12.36	13.54	10.75	9.30	5.81	6.35	51	4.34	4.96	4.97	4.73	5.02	5.81	6.56	5.83	51
(23) FL																							104								104
(24) MS-AL-GA																							2.87	241	2.13	3.10	3.02	4.54	4.46	3.92	241
(25) NC-SC																							5.83	7.33	127	6.93	4.48	7.68	7.25	5.92	127
(26) KY-TN																							4.11	3.93	2.58	149	3.19	4.39	4.72	4.14	149
(27) VA-WVA-MD-DE																							6.65	8.24	4.84	7.66	73	7.83	5.40	5.15	73
(28) MI-IN-OH																							4.93	5.61	3.81	4.63	3.59	0.63	4.33	3.76	
(29) PA																							5.99	7.42	5.46	6.90	3.25	6.53	269	3.49	269
(30) North East																														255	255
Total	162	243	472	72	56	45	76	28	37	18	80	102	133	61	56	36	29	207	62	281	113	127	269	241	188	167	280	557	269	955	5422

*Underscored figures are shipments (in million pounds). Other figures are opportunity costs (in dollars per hundredweight) which result from not having an activity in the optimum solution.

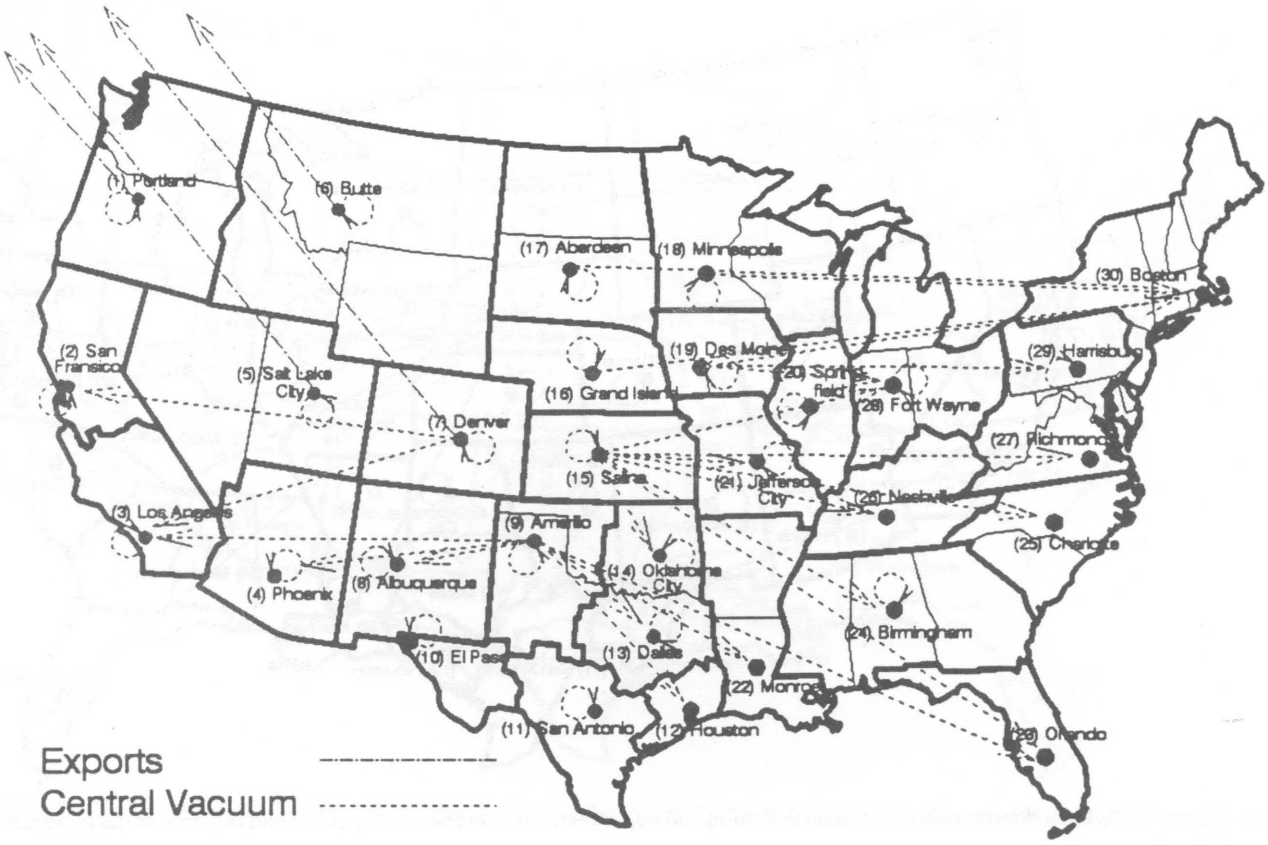

Figure 12. Optimal distribution of vacuum packaged and boxed beef exports with long-run adjustments in merchandising costs and regional shifts in population (Model 7).

Shipment patterns for central-vacuum beef, HRI beef, and export beef were almost identical to those shown for Model 6, Figures 10 and 11.

Central Vacuum. Surplus beef producing regions, such as Kansas, North Dakota-South Dakota, Iowa, and Minnesota-Wisconsin, shipped all of their surplus beef east as central-vacuum beef to markets in the Northeast, the Atlantic states, and the Southeast, Figure 12. Nebraska also shipped some of its surplus beef as central-vacuum beef to the Northeast.

The Texas-Oklahoma Panhandle also shipped all of its surplus beef as central-vacuum beef to markets in the Southeast, the Southwest, and Southern California. Colorado also shipped almost all of its surplus beef as central vacuum-beef west to markets in Southern and Northern California.

HRI. The predominant out-of-state supplier of HRI beef was Nebraska, which shipped HRI beef to markets in the Northeast, the Atlantic Coast states, Cornbelt states, and the Southeast, Figure 13. Other out-of-state suppliers of HRI beef were South Texas, West Texas, and North Dakota-South Dakota.

Boxed Beef. Surplus beef not demanded by domestic markets was exported as boxed beef by Washington-Oregon, Montana-Idaho-Wyoming, Utah-Nevada, and Colorado.

Impact of Regional Shifts in Cattle Feeding

Model 8 was designed to measure the impact on alternative beef packaging/distribution systems assuming that 75 percent of the U.S. fed beef supplies were produced in the Texas-Oklahoma Panhandle, Colorado, Kansas, and Nebraska. The relative distribution of fed beef production among these regions was assumed to be similar to 1988.

The results revealed that optimum alternative packaging/distribution systems as estimated by Model 6 would undergo little or no change as a result of regional shifts in cattle feeding as assumed by Model 8, Figures 14 and 15. If 75 percent of U.S. beef was produced in the Texas-Oklahoma Panhandle, Kansas, Nebraska, and Colorado, the results for Model 8 were as follows: (1) central vacuum accounted for 97 percent of the non-HRI domestic beef merchandised in Model 8 as it did in Model 6, (2) beef production increased approximately 16 percent in the above four regions over 1988 levels, (3) interregional shipments of beef increased almost 8 percent in Model 8 over Model 6 as beef surpluses increased in the four production regions, (4) the shipment patterns for all surplus regions to deficit regions for Model 8 were almost identical to those of Model 6 for domestic central-vacuum and HRI beef, and (5) total beef distribution costs increased less than one-tenth of one percent from Model 6 to Model 8.

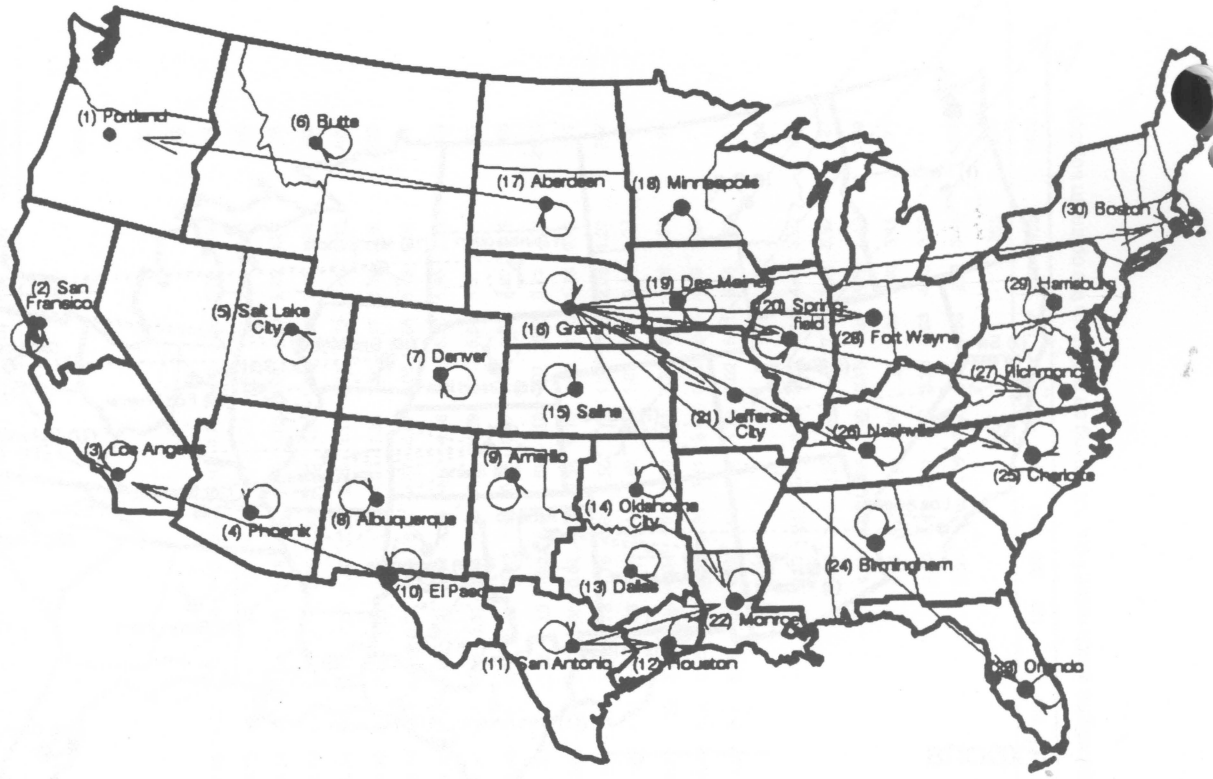

Figure 13. Optimal distribution of HRI beef with long-run adjustments in merchandising costs and regional shifts in population (Model 7).

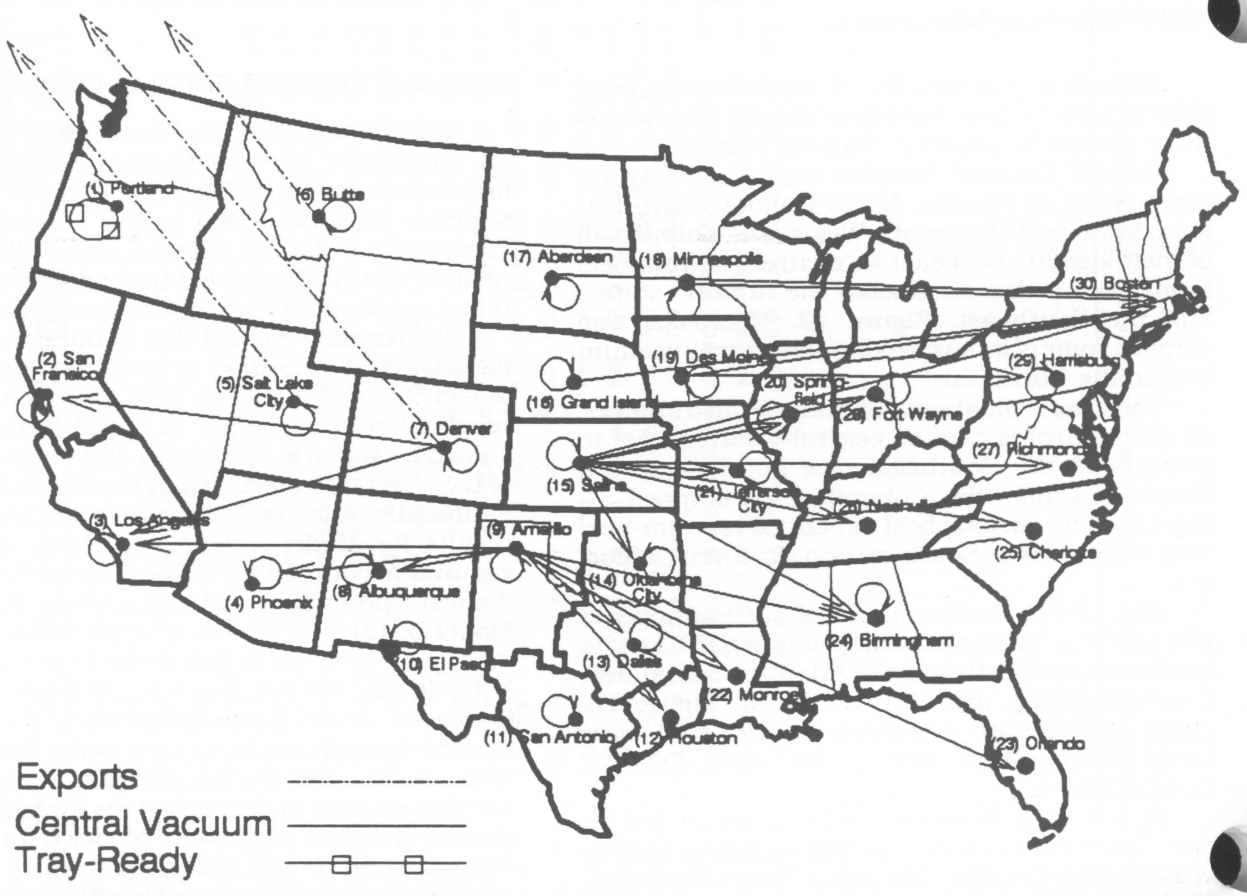

Figure 14. Optimal distribution of vacuum packaged, tray-ready, and boxed beef exports with long-run adjustments in merchandising costs and regional shifts in cattle feeding (Model 8).

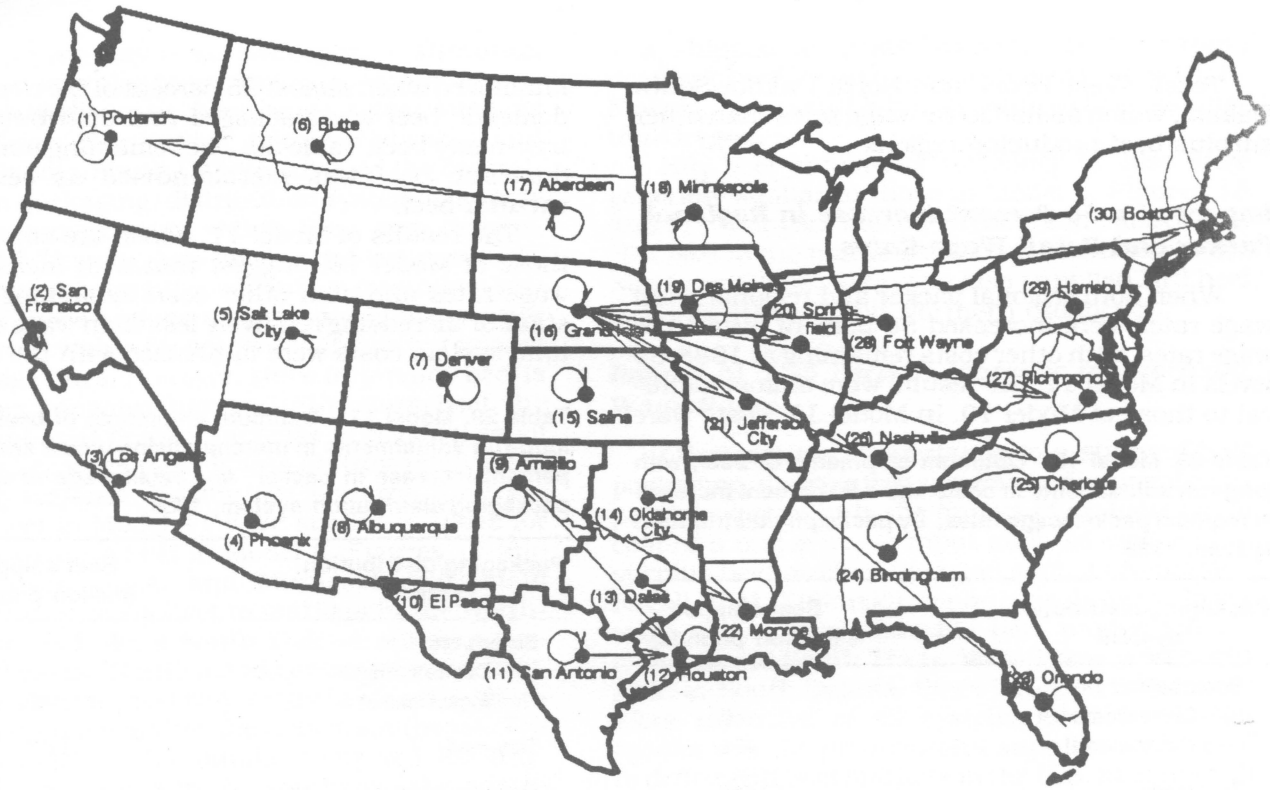

Figure 15. Optimal distribution of HRI beef with long-run adjustments in merchandising costs and regional shifts in population (Model 8).

Combined Impact of Regional Shifts in Population and Cattle Feeding on Alternative Packaging/Distribution Systems

Model 9 reveals that the combined impacts of regional shifts in population and cattle feeding on alternative packaging/distribution systems did not change the optimum packaging/distribution system compared with Model 7. Similarities between Models 7 and 9 were as follows: (1) central-vacuum beef accounted for almost all of the non-HRI domestic beef merchandised, (2) distribution routes were generally unchanged, (3) about 73 and 53 percent of the central-vacuum and HRI beef, respectively, were shipped on an interregional basis in both models, (4) total distribution costs also were almost identical in both models.

Impact of Increases in Regional Wage Rates and Transportation Costs on Alternative Packaging/Distribution Systems

Regional wage rate levels and changes in wage rates impact not only regional competitive advantages and disadvantages, as well as total labor costs, but also competitive advantages of each packaging/distribution system, depending upon the labor intensiveness of each system. Similarly, levels of transportation rates and changes in transportation rates impact not only total distribution costs but also regional shipment patterns and beef shipped on an intraregional and interregional basis. Models 10, 11, and 12 were designed to measure the impact of such changes.

Impact of a 50 Percent Increase in Regional Packer Wage Rates

If regional packer wage rates were to increase 50 percent over 1989 wage rates, with other costs remaining at 1988-89 levels, Model 10 showed that total costs would be minimized when all of the non-HRI domestic beef was packaged and shipped as tray-ready beef, Table 28. These results suggest that with wage rates increasing at a faster rate than other costs, the longer run competitive advantage would tend to favor tray-ready beef over other packaging/distribution systems if such changes in cost structures were to persist.

The regional distribution patterns of tray-ready beef in Model 10 were similar to those for central-vacuum beef in Model 6, Figure 16. Surplus beef production regions, such as Kansas, Iowa, and Minnesota-Wisconsin, shipped their excess tray-ready beef east to markets in the Northeast, the Atlantic Coast, and the southeast. The Texas-Oklahoma Panhandle supplied tray-ready beef to markets in the southeast, the southwest, and Southern California. Colorado shipped surplus tray-ready beef to Southern and Northern California.

Nebraska was the predominant supplier of HRI beef to deficit markets in the Northeast, the Atlantic Coast, the southeast and Northern California. Other surplus HRI regions were South

Texas, West Texas, and North Dakota-South Dakota, which all had lower wage rates than other surplus beef producing regions.

Impact of a 50 Percent Increase in Regional Packer and Retail Wage Rates

When both regional packer and regional retail wage rates were increased 50 percent over 1989 wage rates, with other costs remaining at 1988-89 levels in Model 11, the results were almost identical to those of Model 10. In Model 11, costs were minimized when almost 95 percent of the non-HRI domestic beef was packaged and distributed as tray-ready beef, Table 29. The remaining non-HRI domestic beef was merchandised as central-vacuum beef.

The results of Model 11, which are similar to those of Model 10, suggest that with increasing wage rates and with other costs remaining constant or increasing relatively less than wage rates, total system costs were minimized with the adop

Table 28. Model 10 - Optimum shipments of beef, with long-run adjustments in costs and a 50 percent increase in regional packer wage rates, by packaging/distribution system, 1988.

Packaging/distribution system	Beef shipped (million pounds)
Boxed beef:	
Domestic market	0
Export market	495
Tray-ready	12,649
HRI	5,422
Total shipped	18,566

Table 29. Model 11 - Optimum shipments of beef, with long-run adjustments in merchandising costs and a 50 percent increase in packer and retail wage rates, by packaging/distribution system, 1988.

Packaging/distribution system	Beef shipped (million pounds)
Boxed beef:	
Domestic market	0
Export market	495
Tray-ready	11,837
Central vacuum	812
HRI	5,422
Total shipped	18,566

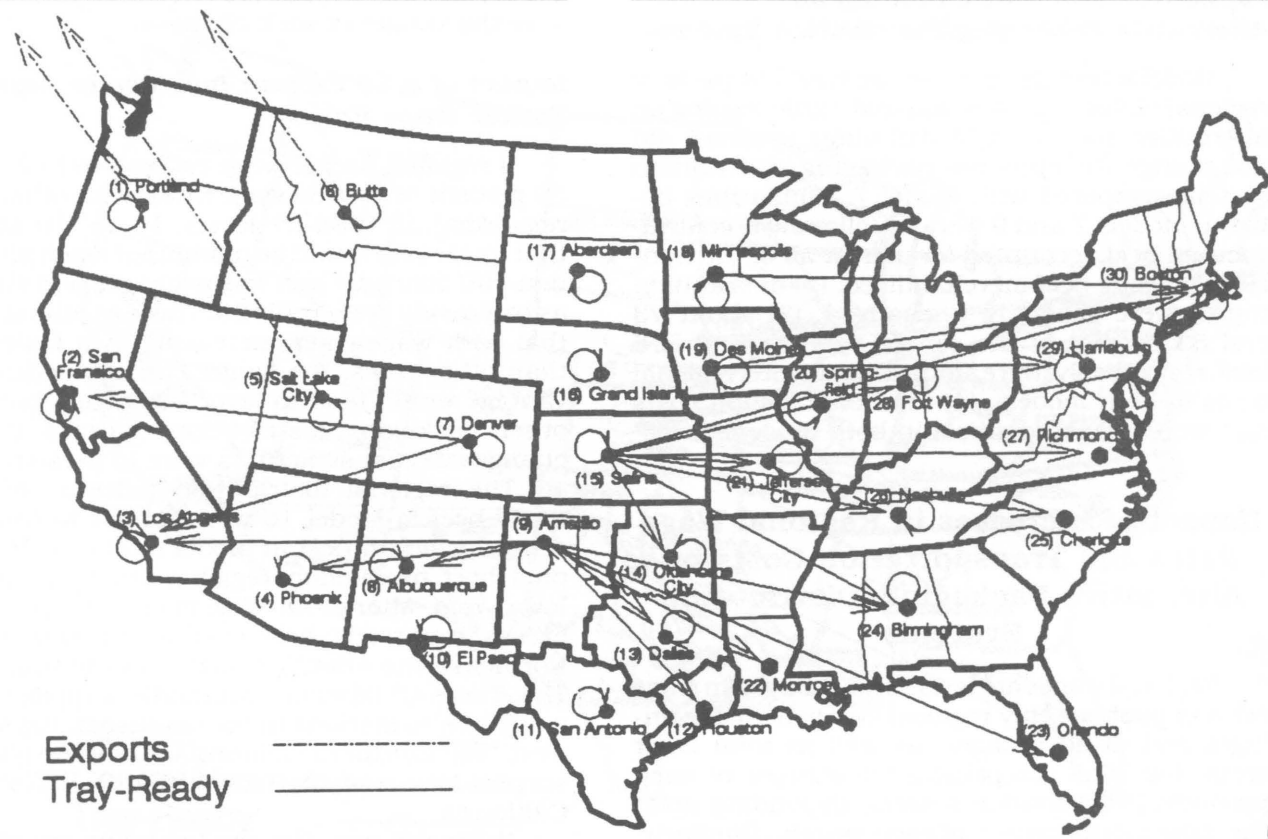

Figure 16. Optimal distribution of tray-ready and boxed-beef exports with long-run adjustments in merchandising costs and increases in regional packer wage rates of 50 percent (Model 10).

tion of the tray-ready packaging/distribution system. It was also important to note that regions with relatively lower base wage rates, such as South Texas, New Mexico, Arizona, Nebraska, and North Dakota-South Dakota, all used the central-vacuum packaging/distribution system to supply beef for consumption within their own regions, Figure 17. This suggests that central-vacuum packaging has a competitive advantage over other systems in those regions with relatively lower wage rates, even with a 50 percent increase in regional base wage rates. However, since tray-ready beef is less labor intensive than central-vacuum beef, the impact of a 50 percent increase in regional retail and packer wage rates is less on tray-ready beef.

The regional distribution patterns for tray-ready beef in Model 11 were similar to those for central-vacuum beef in Model 6, Figures 17 and 10. Kansas, Iowa, and Minnesota-Wisconsin shipped tray-ready beef to markets in the Northeast. North Dakota-South Dakota shipped surplus beef to the Northeast as central-vacuum beef. Kansas also shipped tray-ready beef to the Atlantic Coast states and to the deficit southeast. The Texas-Oklahoma Panhandle competed for tray-ready beef markets in the southeast, the southwest, and Southern California. Colorado shipped surplus beef to Southern California as tray-ready beef, but surplus beef going to Northern California was shipped as central-vacuum beef. Surplus domestic beef was exported as boxed beef by Utah-Nevada, Montana-Idaho-Wyoming, and Washington-Oregon.

HRI beef shipments in Model 11 also were generally similar to those in Model 6, Figures 18 and 11. Nebraska was the predominant supplier of HRI beef to the markets east and southeast of the Northern Plains. Nebraska also supplied HRI beef to the southwest and Northern California.

Impact of a 25 Percent Increase in Nebraska Wage Rates

Of paramount importance to a study of beef packaging/distribution systems and regional competitive alignment is the impact of an increase in cost of a major factor input such as wages on a surplus beef producing region such as Nebraska. Recall that Nebraska reported relatively lower wage costs among surplus beef production regions, as did South Texas, West Texas, and North Dakota-South Dakota. Since HRI beef is the most labor intensive of all systems considered, Nebraska was the predominant supplier of HRI beef to deficit HRI beef markets in the U.S. in almost all models because of its relatively large surplus beef supplies and low regional wage costs. Regions such as West Texas and South Texas, which also

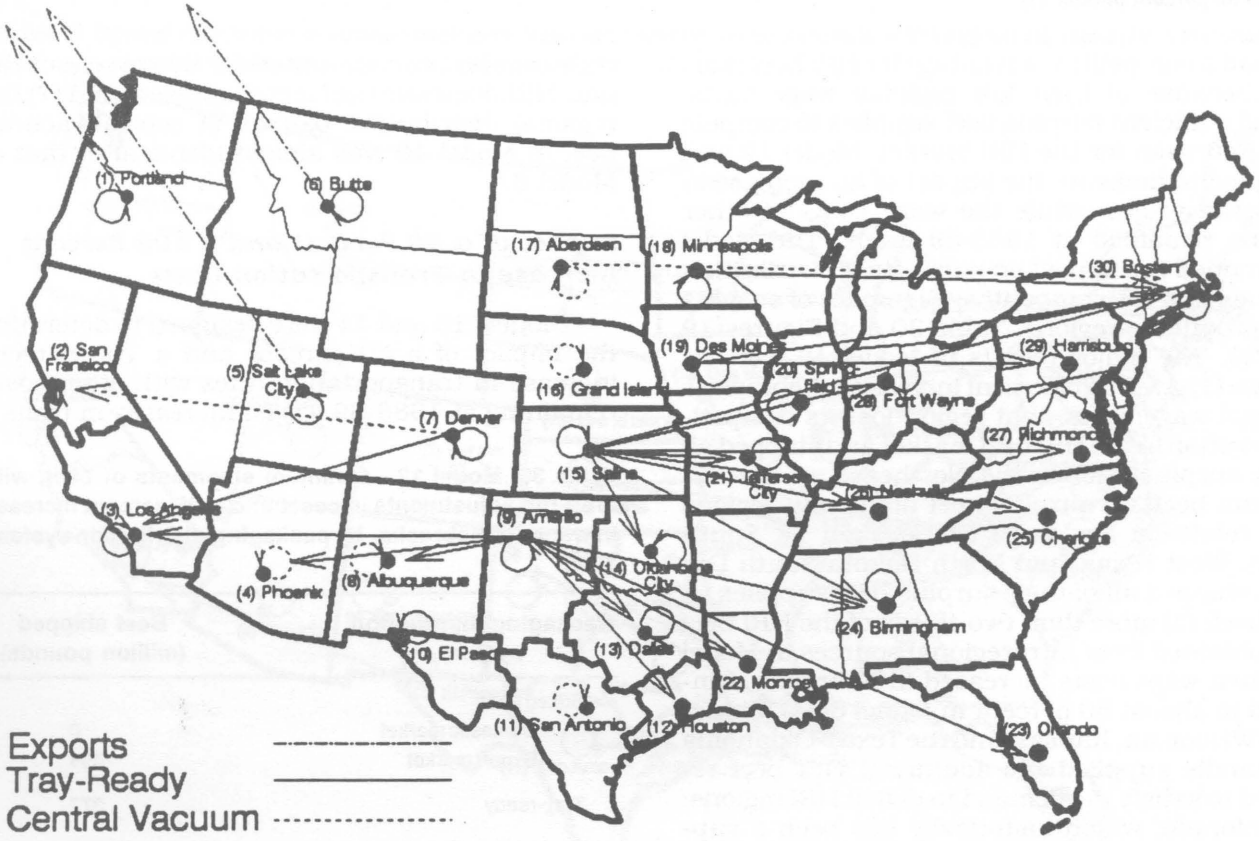

Figure 17. Optimal distribution of tray-ready, vacuum packaged, and boxed beef exports with long-run adjustments in merchandising costs and increases in packer and retail wage rates of 50 percent (Model 11).

Figure 18. Optimal distribution of HRI beef with long-run adjustments in merchandising costs and increases in packer and retail wage rates of 50 percent (Model 11).

had a competitive advantage for HRI beef markets because of their low regional wage costs, lacked sufficient surplus beef supplies to compete with Nebraska for the HRI market. Model 12 was designed to measure the impact of an increase in Nebraska wages, while the wage costs of other regions remained at 1988-89 levels. The Model determined the impact on packaging/distribution systems and the competitive alignment of surplus beef producing regions, Table 30 and Figures 19 and 20. The major results of Model 12 were as follows: (1) given a 25 percent increase in Nebraska's regional wage costs, that region lost its competitive position in the HRI beef market and shipped all of its surplus beef to the Northeast as central-vacuum beef; (2) surplus beef producing regions with relatively low wage costs, such as South Texas, West Texas, and North Dakota-South Dakota, shipped all of their surplus beef supplies as HRI beef; (3) more than two-thirds of the HRI beef was obtained from intraregional sources in Model 12 when wage costs increased in Nebraska compared to almost 50 percent in Model 6; (4) Minnesota-Wisconsin, Kansas, and the Texas-Oklahoma Panhandle supplied the additional HRI beef required to satisfy the demand in deficit HRI regions; (5) Colorado, which historically has been a supplier of HRI beef, remained a primary shipper of central-vacuum beef to the West Coast and a shipper of boxed beef for export along with Nevada-Utah and Montana-Idaho-Wyoming; (6) central-vacuum beef accounted for 97 percent of the non-HRI domestic beef merchandised; and (7) the regional distribution pattern of central-vacuum beef in Model 12 was almost identical to that of Model 6.

Impact of a 50 Percent and a 100 Percent Increase in Transportation Costs

Models 13 and 14 were designed to determine the impact of a 50 percent and a 100 percent increase in transportation rates with other costs remaining at 1988-89 levels. Increases in trans

Table 30. Model 12 - Optimum shipments of beef, with long-run adjustments in costs and a 25 percent increase in wages in Nebraska, by packaging/distribution system, 1988.

Packaging/distribution system	Beef shipped (million pounds)
Boxed beef:	
Domestic market	0
Export market	494
Tray-ready	377
Central vacuum	12,273
HRI	5,422
Total shipped	18,566

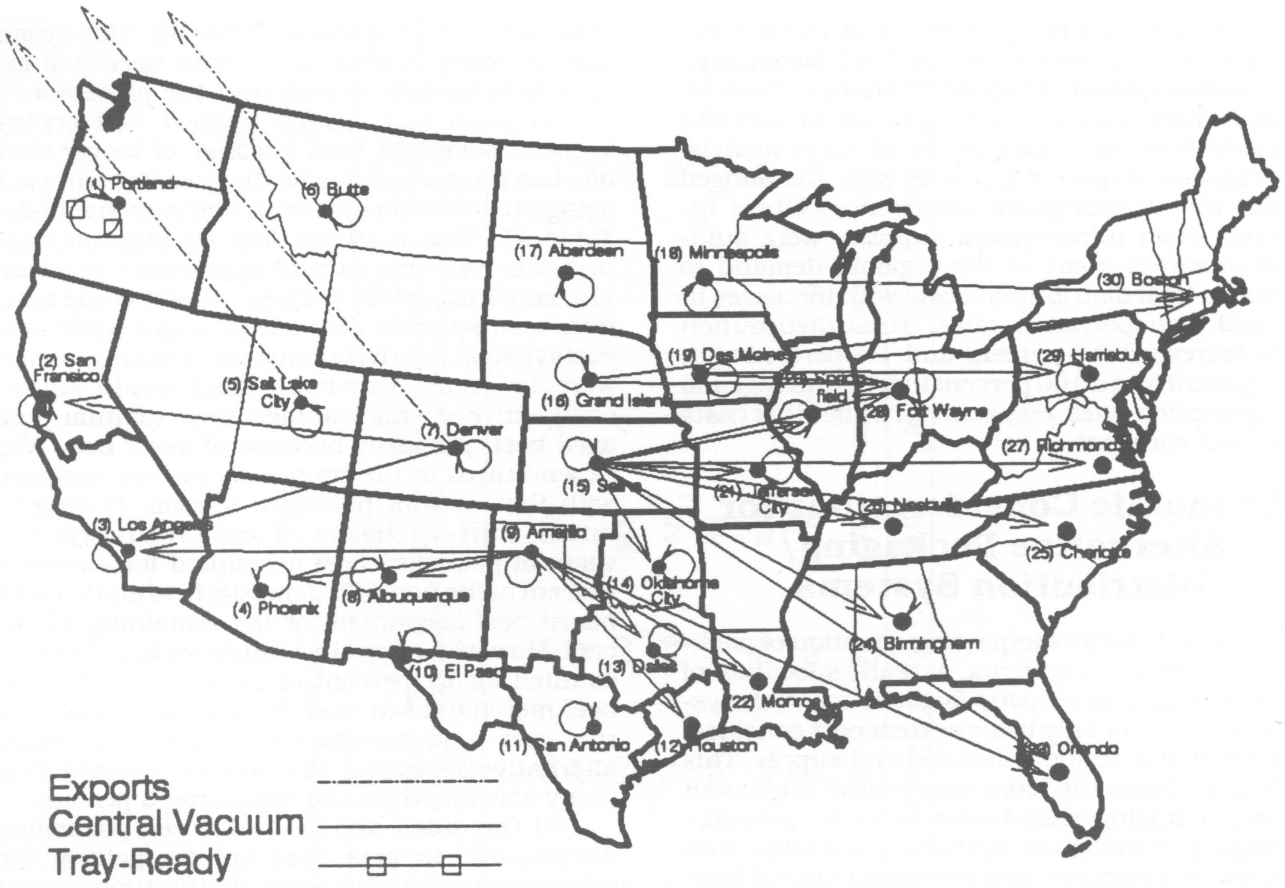

Figure 19. Optimal distribution of vacuum packaged, tray-ready, and boxed beef exports with long-run adjustments in merchandising costs and increases in Nebraska wage rates of 25 percent (Model 12).

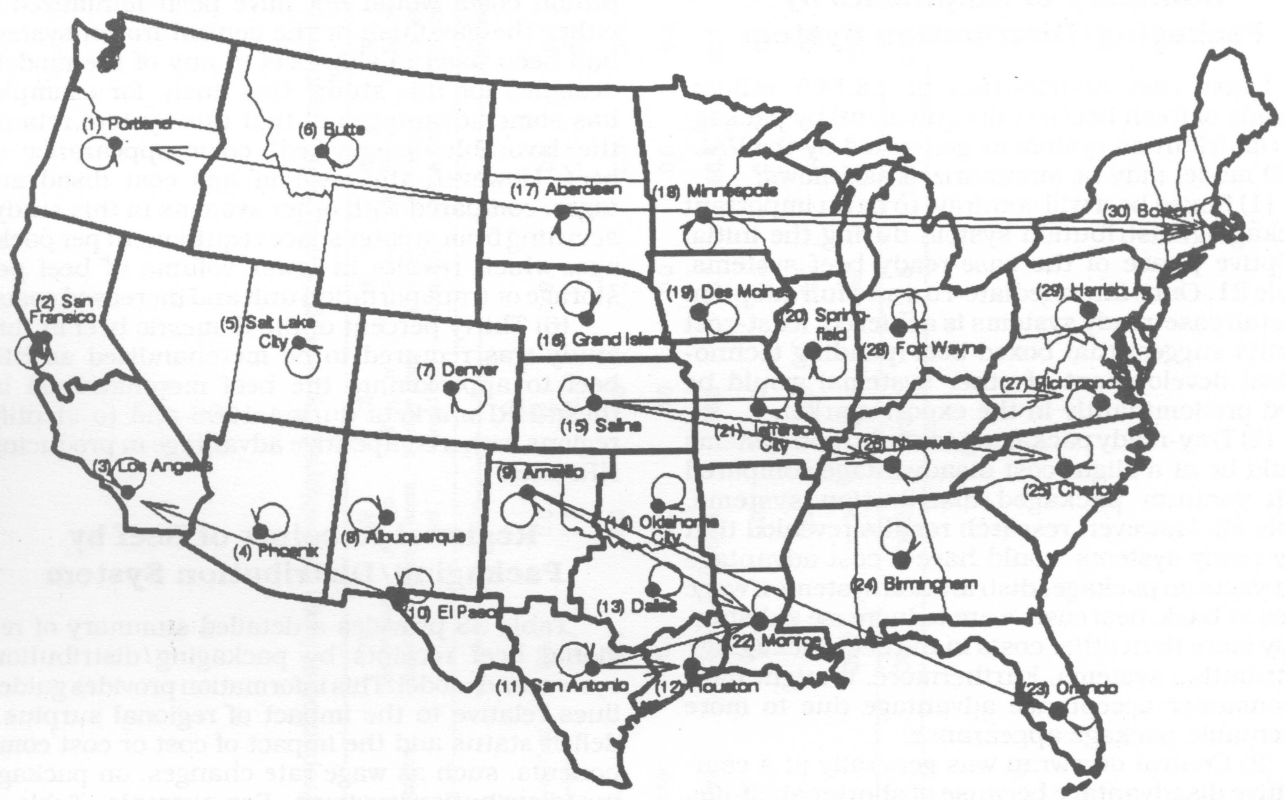

Figure 20. Optimal distribution of HRI beef with long-run adjustments in merchandising costs and increases in Nebraska wage rates of 25 percent (Model 12).

portation rates of 50 percent and 100 percent had no long-run impact on optimal packaging/distribution systems as shown in Model 6. Central-vacuum beef represented 97 percent of non-HRI domestic beef merchandised in all three models. The regional shipment patterns were unchanged except that intraregional shipments of beef increased when intraregional supplies were sufficient to satisfy some of the regional demand to minimize total distribution costs with increases in regional transportation rates. Total distribution costs increased 0.7 percent and 1.4 percent with a 50 percent and a 100 percent increase in regional transportation rates, respectively, while other costs remained constant.

Economic Considerations for Alternative Packaging/ Distribution Systems

Economic factors impacting adoption of packaging/distribution systems, as well as location of fabrication and processing facilities for such systems, involve not only basic system cost considerations but also regional demand and supply. This section analyzes the basic competitive alignment among packaging/distribution systems, potential packaging/distribution systems associated with regional beef markets, and potential regional location for packaging/distribution systems.

Summary of Shipments by Packaging/Distribution System

Least cost distribution of 18,565 million pounds of fresh beef (retail equivalent) by packaging/distribution system as generated by the VAL-ADD model may be summarized as follows:

(1) Boxed beef will continue to be an important packaging/distribution system during the initial adoptive phase of the case-ready beef systems, Table 31. Once intermediate-run and full adoption of retail case-ready systems is achieved, least-cost results suggest that boxed beef (pending technological development of other systems) would be used predominantly in the export market.

(2) Tray-ready packaging/distribution systems would be at a slight cost disadvantage compared with vacuum packaged/distribution systems, Table 32. However, research results revealed that tray-ready systems would have a cost advantage over vacuum package/distribution systems if wage rates or basic beef costs were to increase substantially more than other costs in the beef packaging/distribution systems. Furthermore, it might have a consumer acceptance advantage due to more acceptable package appearance.

(3) Central overwrap was generally at a competitive disadvantage because of shorter shelf-life, compared with central-vacuum and tray-ready systems, but it had a competitive advantage over other alternative systems, Table 32. This system may be more feasible for a chain operating in a metropolitan area located near the processor.

(4) Least cost results suggest that central-vacuum-packaged beef, because of longer shelf-life, has the potential to be the predominant packaging/distribution system in beef merchandising, Table 31. This assumes that vacuum-packaged beef can overcome current appearance problems. The major exception to these results could result from a substantial increase in wages while other costs remain relatively constant. If such a scenario were to occur, tray-ready beef would enjoy a competitive cost advantage over vacuum-packaged beef, primarily because of lower base wage expenditures in the tray-ready system compared with the vacuum packaged system. During the initial start-up phase of case-ready systems, vacuum-packaged beef accounted for almost 53 percent of the non-HRI domestic beef market while boxed beef accounted for the remaining 47 percent. However, central-vacuum-packaged beef accounted for 97 percent of the non-HRI domestic beef merchandised once intermediate- and long-run cost adjustments were allowed to impact alternative packaging/distribution systems. Tray-ready accounted for the remaining 3 percent.

(5) Gas-flush and central-frozen packaging/distribution systems were not competitive with other alternative packaging/distribution systems under the various models designed for this study. These results suggest that total packaging/distribution costs would not have been minimized if either the gas-flush or the central-frozen system had been used to ship beef in any of the models designed for this study. Gas flush, for example, has some advantages in that this system retains the favorable "cherry-red" color appearance of beef. However, this system has cost disadvantages, compared with other systems in this study, accruing from greater space requirement per package, which results in lower volume of beef per storage or transportation unit and increased costs.

(6) Thirty percent of the domestic beef in this study was required to be merchandised as HRI beef to approximate the beef merchandised in these HRI markets during 1988 and to identify regions with a competitive advantage in producing HRI beef.

Regional Receipts of Beef by Packaging/Distribution System

Table 33 provides a detailed summary of regional beef receipts by packaging/distribution system and model. This information provides guidelines relative to the impact of regional surplus/deficit status and the impact of cost or cost components, such as wage rate changes, on packaging/distribution systems. For example, Table 1 revealed that packer wage rates in the contiguous 48 states were highest in Washington-Oregon.

Table 31. Proportion of fresh beef shipped, by packaging/distribution system and by model employed, 1988.

Packaging/Distribution System	(1) Conventional Boxed Beef	(2) Alt. Sys. w/out Merch. Cost	(3) Alt. Sys. w/ Start-up Costs -Boxed Beef	(4) Alt. Sys. w/ Short-run Merch. Cost	(5) Alt. Sys. w/ Intermed.-run Merch. Cost	(6) Alt. Sys. w/ Long-run Adjustments	(7) Alt. Sys. w/ Long-run adj. & Pop. shifts	(8) Alt. Sys. w/ Shifts in Cattle feeding	(9) Alt. Sys. w/ Shifts in pop. &Cattle feeding	(10) Alt. Sys. w/ Packer wage Rates Inc. 50%	(11) Alt. Sys. w/ 50% Increase in Wage rates	(12) Alt. Sys. w/ Nebraska Wage Rates Inc. 25%	(13) Alt. Sys. w/ 50% Increase trans. costs	(14) Alt. Sys. w/ 100% Increase trans. costs
	Percent beef shipped													
Boxed beef:														
Domestic market	68.1	0.0	32.1	9.4	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Export market	2.7	2.7	2.7	2.7	2.7	2.7	2.7	2.7	2.7	2.7	2.7	2.7	2.7	2.7
Tray-ready	0.0	0.0	0.0	2.0	2.0	2.0	0.0	2.0	2.0	68.1	63.7	2.0	2.0	2.0
Central overwrap	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Central vacuum	0.0	68.1	36.0	56.7	66.1	66.1	68.1	66.1	66.1	0.0	4.4	66.1	66.1	66.1
Central gas	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Central frozen	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
HRI	29.2	29.2	29.2	29.2	29.2	29.2	29.2	29.2	29.2	29.2	29.2	29.2	29.2	29.2
Total	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0

Table 32. Beef and packaging/distribution cost, by system and cost categories, packers, retailers, and total costs, long-run adoption (Model 6), 1988.[a]

Item	System						
	Boxed Beef	Tray-Ready	Central Overwrap	Central Vacuum	Central Gas	Central Frozen	Central HRI
	dollars/cwt						
Packers:							
Carcass	165.48	165.48	165.48	165.48	165.48	165.48	165.48
Fixed	0.84	1.10	1.00	1.18	1.18	1.18	0.93
Labor	2.86	5.53	9.73	9.76	9.76	9.76	16.06
Package	2.24	2.60	5.21	10.10	18.43	10.10	10.10
Distribution	2.75	2.75	5.35	2.75	3.72	2.27	4.20
Other	2.86	5.53	5.84	5.84	6.84	11.54	11.78
Sub-Total	177.03	182.99	192.61	195.11	205.41	200.33	208.55
Retailers:							
Fixed	7.72	6.72	6.32	6.32	6.32	8.49	13.52
Labor	25.56	15.75	14.59	14.63	14.63	14.63	19.63
Package	5.20	5.20	0.00	0.00	0.00	0.00	0.00
Distribution	3.11	3.11	0.00	3.11	3.53	2.57	3.70
Other	24.89	21.89	24.14	15.49	16.54	15.49	11.29
Sub-Total	66.48	52.67	45.05	39.55	41.02	41.18	48.14
Total Cost:							
Carcass	165.48	165.48	165.48	165.48	165.48	165.48	165.48
Fixed	8.56	7.82	7.32	7.50	7.50	9.67	14.45
Labor	28.42	21.28	24.32	24.39	24.39	24.39	35.69
Package	7.44	7.80	5.21	10.10	18.43	10.10	10.10
Distribution	5.86	5.86	5.35	5.86	7.25	4.84	7.90
Other	27.75	27.42	29.98	21.33	23.38	27.03	23.07
Total System	243.51	235.66	237.66	234.66	246.43	241.51	256.69

[a]Average costs for 48 states in terms of 1988 prices. Higher carcass prices in 1990 would increase these total costs by about $15/cwt.

The packaging/distribution system most predominant in Washington-Oregon for the 14 models analyzed in this study was tray-ready, Table 33. The tray-ready system was not the predominant packaging/distribution system in any of the other regions over the entire range of models specified. However, the tray-ready system was used by almost all regions when wage rates were systematically increased in all regions while other costs remained constant, as in Models 10 and 11. These results suggest the tray-ready packaging/distribution system has a competitive advantage over other systems when wage rates are relatively high or increase relatively faster than do other costs.

The predominant packaging/distribution system for all regions, with the exception of Washington-Oregon, was central-vacuum packaging, given long-run adjustments in costs and without increases in wage rates relative to other costs, Table 33. These results suggest that the vacuum packaging/distribution system has a competitive advantage over other packaging/distribution systems, given the industry cost conditions, including the relationship of the various cost items during 1988, along with long run adjustments in merchandising costs.

The surplus/deficit status of a region had little or no impact on type of packaging/distribution system utilized as the pattern of packaging/distribution systems were generally similar for all regions, Table 33.

Table 33. Regional proportion of non-HRI domestic fresh beef received by packaging/distribution system and model employed, 1988.

Receiving Region/Area[a]	(1) Conventional Boxed Beef	(2) Alt. Sys. w/out Merch. Cost	(3) Alt. Sys. w/ Start-up Costs -Boxed Beef	(4) Alt. Sys. w/ Short-run Merch. Cost	(5) Alt. Sys. w/ Intermed.-run Merch. Cost	(6) Alt. Sys. w/ Long-run Adjustments	Alt. Sys. w/ Long-run adj. & Pop. shifts	(8) Alt. Sys. w/ Shifts in Cattle Feeding	(9) Alt. Sys. w/ Shifts in pop. &Cattle feeding	(10) Alt. Sys. w/ Packer wage Rates Inc. 50%	(11) Alt. Sys. w/ 50% Increase in Wage rates	(12) Alt. Sys. w/ Nebraska Wage Rates Inc. 25%	(13) Alt. Sys. w/ 50% Increase trans. costs	(14) Alt. Sys. w/ 100% Increase trans. costs
	Percent received by alternative packaging system*													
WA-OR	BB (100%)	CV (100%)	BB (100%)	TR (100%)	TR (100%)	TR(100%)	CV (100%)	TR(100%)	TR (100%)	TR (100%)	TR (100%)	TR (100%)	TR (100%)	TR (100%)
N. CA	BB (100%)	CV (100%)	CV (100%)	CV (100%)	CV (100%)	CV (100%)	CV (100%)	CV (100%)	CV (100%)	TR (100%)	TR (69.2%) CV (30.8%)	CV (100%)	CV (100%)	CV (100%)
S. CA	BB (100%)	CV (100%)	CV (100%)	CV (100%)	CV (100%)	CV (100%)	CV (100%)	CV (100%)	CV (100%)	TR (100%)	TR (100%)	CV (100%)	CV (100%)	CV (100%)
AZ	BB (100%)	CV (100%)	BB (22.6%) CV (77.4%)	CV (100%)	CV (100%)	CV (100%)	CV (100%)	CV (100%)	CV (100%)	TR (100%)	TR (22.6%) CV (77.4%)	CV (100%)	CV (100%)	CV (100%)
UT-NV	BB (100%)	CV (100%)	BB (100%)	CV (100%)	CV (100%)	CV (100%)	CV (100%)	CV (100%)	CV (100%)	TR (100%)	TR (100%)	CV (100%)	CV (100%)	CV (100%)
MT-ID-WY	BB (100%)	CV (100%)	BB (100%)	BB (100%)	CV (100%)	CV (100%)	CV (100%)	CV (100%)	CV (100%)	TR (100%)	TR (100%)	CV (100%)	CV (100%)	CV (100%)
CO	BB (100%)	CV (100%)	BB (100%)	CV (100%)	CV (100%)	CV (100%)	CV (100%)	CV (100%)	CV (100%)	TR (100%)	TR (100%)	CV (100%)	CV (100%)	CV (100%)
NM	BB (100%)	CV (100%)	BB (41.5%) CV (58.5%)	CV (100%)	CV (100%)	CV (100%)	CV (100%)	CV (100%)	CV (100%)	TR (100%)	TR (41.5%) CV (58.5%)	CV (100%)	CV (100%)	CV (100%)
TX-OK PAN.	BB (100%)	CV (100%)	BB (100%)	CV (100%)	CV (100%)	CV (100%)	CV (100%)	CV (100%)	CV (100%)	TR (100%)	TR (100%)	CV (100%)	CV (100%)	CV (100%)
W. TX	BB (100%)	CV (100%)	BB (100%)	CV (100%)	CV (100%)	CV (100%)	CV (100%)	CV (100%)	CV (100%)	TR (100%)	TR (100%)	CV (100%)	CV (100%)	CV (100%)
S. TX	BB (100%)	CV (100%)	BB (100%)	CV (100%)	CV (100%)	CV (100%)	CV (100%)	CV (100%)	CV (100%)	TR (100%)	CV (100%)	CV (100%)	CV (100%)	CV (100%)
SE. TX	BB (100%)	CV (100%)	CV (100%)	CV (100%)	CV (100%)	CV (100%)	CV (100%)	CV (100%)	CV (100%)	TR (100%)	TR (100%)	CV (100%)	CV (100%)	CV (100%)
E. TX	BB (100%)	CV (100%)	BB (100%)	CV (100%)	CV (100%)	CV (100%)	CV (100%)	CV (100%)	CV (100%)	TR (100%)	TR (100%)	CV (100%)	CV (100%)	CV (100%)
E. OK	BB (100%)	CV (100%)	BB (100%)	BB (100%)	CV (100%)	CV (100%)	CV (100%)	CV (100%)	CV (100%)	TR (100%)	TR (100%)	CV (100%)	CV (100%)	CV (100%)
KS	BB (100%)	CV (100%)	CV (100%)	CV (100%)	CV (100%)	CV (100%)	CV (100%)	CV (100%)	CV (100%)	TR (100%)	TR (100%)	CV (100%)	CV (100%)	CV (100%)
NE	BB (100%)	CV (100%)	CV (100%)	CV (100%)	CV (100%)	CV (100%)	CV (100%)	CV (100%)	CV (100%)	TR (100%)	TR (100%)	CV (100%)	CV (100%)	CV (100%)
ND-SD	BB (100%)	CV (100%)	BB (100%)	CV (100%)	CV (100%)	CV (100%)	CV (100%)	CV (100%)	CV (100%)	TR (100%)	CV (100%)	CV (100%)	CV (100%)	CV (100%)
MN-WI	BB (100%)	CV (100%)	CV (100%)	CV (100%)	CV (100%)	CV (100%)	CV (100%)	CV (100%)	CV (100%)	TR (100%)	TR (100%)	CV (100%)	CV (100%)	CV (100%)
IA	BB (100%)	CV (100%)	BB (100%)	CV (100%)	CV (100%)	CV (100%)	CV (100%)	CV (100%)	CV (100%)	TR (100%)	TR (100%)	CV (100%)	CV (100%)	CV (100%)
IL	BB (100%)	CV (100%)	CV (100%)	CV (100%)	CV (100%)	CV (100%)	CV (100%)	CV (100%)	CV (100%)	TR (100%)	TR (100%)	CV (100%)	CV (100%)	CV (100%)
MO	BB (100%)	CV (100%)	BB (100%)	CV (100%)	CV (100%)	CV (100%)	CV (100%)	CV (100%)	CV (100%)	TR (100%)	TR (100%)	CV (100%)	CV (100%)	CV (100%)
AR-LA	BB (100%)	CV (100%)	BB (100%)	BB (100%)	CV (100%)	CV (100%)	CV (100%)	CV (100%)	CV (100%)	TR (100%)	TR (100%)	CV (100%)	CV (100%)	CV (100%)
FL	BB (100%)	CV (100%)	BB (100%)	CV (100%)	CV (100%)	CV (100%)	CV (100%)	CV (100%)	CV (100%)	TR (100%)	TR (100%)	CV (100%)	CV (100%)	CV (100%)
MS-AL-GA	BB (100%)	CV (100%)	BB (100%)	BB (86.9%) CV (13.1%)	CV (100%)	CV (100%)	CV (100%)	CV (100%)	CV (100%)	TR (100%)	TR (100%)	CV (100%)	CV (100%)	CV (100%)
NC-SC	BB (100%)	CV (100%)	BB (100%)	BB (81.1%) CV (18.9%)	CV (100%)	CV (100%)	CV (100%)	CV (100%)	CV (100%)	TR (100%)	TR (100%)	CV (100%)	CV (100%)	CV (100%)
KY-TN	BB (100%)	CV (100%)	CV (100%)	CV (100%)	CV (100%)	CV (100%)	CV (100%)	CV (100%)	CV (100%)	TR (100%)	TR (100%)	CV (100%)	CV (100%)	CV (100%)
VA-WVA-MD-DE	BB (100%)	CV (100%)	CV (100%)	CV (100%)	CV (100%)	CV (100%)	CV (100%)	CV (100%)	CV (100%)	TR (100%)	TR (100%)	CV (100%)	CV (100%)	CV (100%)
MI-IN-OH	BB (100%)	CV (100%)	BB (100%)	CV (100%)	CV (100%)	CV (100%)	CV (100%)	CV (100%)	CV (100%)	TR (100%)	TR (100%)	CV (100%)	CV (100%)	CV (100%)
PA	BB (100%)	CV (100%)	BB (100%)	BB (56.4%) CV (43.6%)	CV (100%)	CV (100%)	CV (100%)	CV (100%)	CV (100%)	TR (100%)	TR (100%)	CV (100%)	CV (100%)	CV (100%)
North East	BB (100%)	CV (100%)	CV (100%)	CV (100%)	CV (100%)	CV (100%)	CV (100%)	CV (100%)	CV (100%)	TR (100%)	TR (94.1%) CV(5.9%)	CV (100%)	CV (100%)	CV (100%)

*BB = Boxed Beef, TR = Tray-Ready, CV = Central Vacuum

[a]Shaded regions are excess supply (surplus) regions. Regions not shaded are excess demand (deficit) regions.

Total Retail Beef Cost and Retail Cost Differentials by Region and Packaging/Distribution System

Analysis of packaging/distribution systems revealed that the central-vacuum system generally enjoyed a competitive cost advantage over other packaging/distribution systems, Table 34. The second and third most competitive systems with respect to cost were tray-ready and central overwrap, respectively. The next lowest cost system was the central-frozen system followed by boxed beef.

The VAL-ADD model designed for this study can be used to measure the impact of various cost components at the regional or national level upon the total beef distribution cost. For example, the assumptions and basic costs in Models 6 and 12 were identical except that Model 12 assumed an arbitrary 25 percent increase in Nebraska wage rates. Changes in regional costs, such as labor, impact not only the competitive alignment of packaging/distribution systems and regional distribution patterns but also costs to the total beef distribution system. A 25 percent increase in Nebraska wage rates resulted in an overall increase to the beef distribution system of 15 cents per hundredweight (241.44 minus 241.29) or an increased cost of $27.5 million dollars.

Total beef retail cost differentials by model and packaging/distribution system provide information concerning the competitive alignment of packaging/distribution systems as cost components undergo change. The VAL-ADD model revealed generally lowest total retail costs for central-vacuum-packaged beef, Table 35. Further comparison of retail costs by packaging/distribution system revealed that tray-ready and central overwrap ranked second and third, respectively, relative to lowest retail costs, Table 35. Ranked next lowest were central-frozen and boxed-beef packaging/distribution systems. However, cost differentials also provide clues relative to the competitive alignment and changes in competitive alignment as cost components undergo change. For example, Model 10 measured the impact on packaging/distribution systems from a 50 percent increase in regional packer wage rates. The VAL-ADD model showed that if such a scenario were to occur, with other costs remaining unchanged, tray-ready-packaged beef would enjoy a $1.14/hundredweight competitive advantage over vacuum-packaged beef, Table 35. The results also imply that tray-ready-packaged beef would enjoy a $4.35/hundredweight cost advantage over central overwrap given the cost assumptions of Model 10. Further, the price differentials for Models 13 and 14 show that with increases in transportation costs relative to other costs, central overwrap becomes more competitive since costs to the total beef distribution system are minimized when increasing proportions of beef are shipped (merchandised) by a packaging/distribution system oriented toward more nearby markets as is central overwrap.

Although the average retail cost difference between central vacuum and boxed beef packaging/distribution systems was $8.85 per hundredweight ($243.51 minus $234.66) in Model 6 (Table 35), regional cost differences between packaging/distribution systems vary depending upon distance between surplus and deficit regions, regional labor rates, and regional beef prices. Retail cost differences between boxed beef and central-vacuum-packaged beef in Model 6, which assumed long-run adjustments, ranged from $5.69 to $14.67 and involved shipments from the Texas-Oklahoma Panhandle to various destinations, Table 36. Similarly, retail cost differentials between boxed beef and central-vacuum-packaged beef for shipments from Kansas to various destinations ranged from $5.31 to $14.30 per hundredweight.

Potential Location and Economic Impact of Regional Increases in Beef Supplies by Packaging/Distribution System

The VAL-ADD model also generated cost reductions (shadow costs) which could accrue, theoretically, if beef supplies were increased by one unit (hundredweight). Table 37 provides cost reductions by region and model designed for this study. Regions with highest cost reductions across all models were Virginia-West Virginia-Maryland-Delaware and Florida. For example, results suggest that given the regional cost, supply, and demand conditions posited in Model 10, total distribution costs as estimated by the VAL-ADD model could be decreased $14.14 if beef supplied in Florida were increased one unit (hundredweight). This assumes that Florida has the capacity and/or facilities to perform the necessary fabrication/packaging services. More importantly, these cost reductions reveal that, given the assumptions and basic data in Model 10, Florida and Virginia-West Virginia-Maryland-Delaware have more potential to decrease total packaging/distribution costs than do other regions, Table 37.

Regions with the largest cost reductions (Regions 27 and 23) have several common attributes. These regions are (1) large deficit regions and (2) located relatively long distances from surplus beef regions, which translates into higher transportation costs per unit of beef received. Conversely, regions such as Montana-Idaho-Wyoming (6) reveal "0" cost reductions across all models, which suggests that costs to the system would not be decreased by the fabrication of additional units in that region.

The Montana-Idaho-Wyoming region has a competitive disadvantage with most other surplus beef regions since it is located relatively long

Table 34. Average total beef retail cost, by model and packaging/distribution system, 1988.

Packaging/Distribution System	1[a] Conventional Boxed Beef	2 Alt. Sys. w/out Merch. Cost	3 Alt. Sys. w/ Start-up Costs -Boxed Beef	4 Alt. Sys. w/ Short-run Merch. Cost	5 Alt. Sys. w/ Intermed.-run Merch. Cost	6[b] Alt. Sys. w/ Long-run Adjustments	10 Alt. Sys. w/ Packer wage Rates Inc. 50%	11 Alt. Sys. w/ 50% Increase in Wage rates	12 Alt. Sys. w/ Nebraska Wage Rates Inc. 25%	13 Alt. Sys. w/ 50% Increase trans. costs	14 Alt. Sys. w/ 100% Increase trans. costs
	dollars/cwt										
Boxed beef	243.51	243.51	243.51	243.51	243.51	243.51	246.09	258.12	244.64	246.59	248.56
Tray-ready	0.0	240.50	244.66	241.66	238.66	235.66	239.05	246.30	235.74	237.75	239.82
Central overwrap	0.0	241.94	246.66	243.66	240.66	237.66	243.40	249.82	237.78	238.28	239.25
Central vacuum	0.0	238.89	243.66	240.53	237.53	234.66	240.19	246.73	234.66	236.62	238.69
Central gas	0.0	250.79	255.43	252.43	249.43	246.43	252.08	258.62	246.55	248.50	250.56
Central frozen	0.0	245.87	250.51	247.51	244.51	241.51	247.17	253.71	241.64	243.60	245.67
Central HRI	262.50	262.50	256.69	256.69	256.69	256.69	265.84	274.54	256.90	258.76	260.83

[a]Boxed beef and Central HRI were the only systems considered in model 1.

[b]Models 7, 8, and 9 were identical to Model 6.

Table 35. Average total beef retail cost differentials, by model and packaging/distribution system, 1988[a].

Packaging/Distribution System	1[b] Conventional Boxed Beef	2 Alt. Sys. w/out Merch. Cost	3 Alt. Sys. w/ Start-up Costs -Boxed Beef	4 Alt. Sys. w/ Short-run Merch. Cost	5 Alt. Sys. w/ Intermed.-run Merch. Cost	6[c] Alt. Sys. w/ Long-run Adjustments	10 Alt. Sys. w/ Packer wage Rates Inc. 50%	11 Alt. Sys. w/ 50% Increase in Wage rates	12 Alt. Sys. w/ Nebraska Wage Rates Inc. 25%	13 Alt. Sys. w/ 50% Increase trans. costs	14 Alt. Sys. w/ 100% Increase trans. costs
	dollars/cwt										
Boxed beef	243.51	4.62	-0.15	2.98	5.98	8.85	5.90	11.39	9.98	9.97	9.87
Tray-ready	0.0	1.61	1.00	1.13	1.13	1.00	-1.14	-0.43	1.08	1.13	1.13
Central overwrap	0.0	3.05	3.00	3.13	3.13	3.00	3.21	3.09	3.12	1.66	0.56
Central vacuum	0.0	238.89	243.66	240.53	237.53	234.66	240.19	246.73	234.66	236.62	238.69
Central gas	0.0	11.90	11.77	11.90	11.90	11.77	11.89	11.89	11.89	11.88	11.87
Central frozen	0.0	6.98	6.85	6.98	6.98	6.85	6.98	6.98	6.98	6.98	6.98
Central HRI	262.50	23.61	13.03	16.16	19.16	22.03	25.65	27.81	22.24	22.14	22.14

[a]The Central Vacuum packaging/distribution system was arbitrarily selected as a base for calculating cost differentials.

[b]Boxed beef and Central HRI were the only systems considered in model 1.

[c]Models 7, 8, and 9 were identical to Model 6.

Table 36. Comparison of retail costs for boxed beef and central vacuum packaged systems, selected routes, Texas-Oklahoma Panhandle and Kansas[a].

Destination Region	(9) TX-OK-Pan			(15) KS		
	Boxed Beef	Central Vacuum	Boxed Beef vs. Central Vac. Costs	Boxed Beef	Central Vacuum	Boxed Beef vs. Central Vac. Costs
	(cents per retail pound)					
(2) N. CA	255.53	240.86	14.67	256.11	241.81	14.30
(3) S. CA	248.38	236.90[b]	11.48	248.98	237.87	11.11
(9) TX-OK PAN	233.65	226.71[b]	6.95	237.50	230.93	6.57
(10) W. TX	238.95	231.21	7.74	239.74	232.38	7.36
(11) S. TX	235.89	229.84	6.05	236.30	230.62	5.68
(12) SE. TX	242.47	233.35[b]	9.12	242.66	233.92	8.74
(13) E. TX	241.00	232.31[b]	8.69	241.20	232.89	8.31
(14) E. OK	234.49	228.80	5.69	234.31	229.00[b]	5.31
(15) KS	242.46	233.05	9.41	238.89	229.86[b]	8.94
(16) NE	240.08	232.03	8.05	239.79	232.12	7.67
(20) IL	247.25	235.73	11.52	246.81	235.65	11.16
(23) FL	240.61	232.55[b]	8.06	240.68	232.99[b]	7.69
(24) MS-AL-GA	235.73	229.76	5.97	235.66	230.06[b]	5.60
(25) NC-SC	238.65	232.33	6.32	238.46	232.52[b]	5.96
(27) VA-W.VA-MD-DE	250.72	238.74	11.98	250.42	238.81[b]	11.61
(29) PA	243.65	232.81	10.84	239.03	232.93	6.10
(30) North East	248.96	238.11	10.85	248.68	238.19[b]	10.49

[a]Costs are based on Model 6 that assumes long-run adjustments have been made at retail stores.

[b]Optimal routes

distances from most major beef markets. Minnesota-Wisconsin accrued relatively low cost reductions since that region competes in one market (Northeast) with other major surplus regions, but it has a locational disadvantage with respect to most other deficit markets. Colorado also had "0" cost reductions for most models analyzed. Although Colorado competed for the California market with Texas-Oklahoma, it reported relatively higher wage rates than did most other surplus beef regions. In addition, Kansas, Nebraska, and Iowa have a locational advantage to the eastern beef markets compared with Colorado.

The Texas regions with the largest potential for reducing costs to the total system were Southeast Texas (12), South Texas (11) and East Texas (13). The major common attribute of these regions is relatively low wage rates (Table 1) compared with most other regions.

Major surplus regions such as the Texas-Oklahoma Panhandle, Kansas, and Nebraska accrued relatively low cost reduction coefficients over all models as expected. The largest cost reductions in these three regions were in Nebraska, which reported the lowest packer wage rates of these three regions (Table 1).

Potential Beef Markets by Region and Packaging/Distribution System

The VAL-ADD model also provided "least-cost opportunity routes", which provide information relative to the next or potential packaging/distribution system, by model and shipping/receiving region, which would have come into the least cost solutions if costs (transportation, packaging, etc.) were decreased by the specified amounts, Table 38. For example, Model 2 revealed that central-vacuum-packaged beef would have been the next packaging/distribution system to enter the least-cost solution, in addition to those already in the solution, on shipments from Region 15 (Kansas) to Region 20 (Illinois) provided packaging/distribution costs decrease at least $0.01 per hundredweight. The next or second packaging/distribution system potentially entering the optimum solution for Model 2 would be central-vacuum beef on shipments from Region 16 (Nebraska) to Region

Table 37. Potential cost reductions associated with increases in beef supplies, by region and packaging/distribution system, 1988.

Supply Region	(1) Conventional Boxed Beef	(2) Alt. Sys. w/out Merch. Cost	(3) Alt. Sys. w/ Start-up Costs -Boxed Beef	(4) Alt. Sys. w/ Short-run Merch. Cost	(5) Alt. Sys. w/ Intermed.-run Merch. Cost	(6) Alt. Sys. w/ Long-run Adjustments	(7) Alt. Sys. w/ Long-run adj. & Pop. shifts	(8) Alt. Sys. w/ Shifts in Cattle Feeding	(9) Alt. Sys. w/ Shifts in pop. & Cattle feeding	(10) Alt. Sys. w/ Packer wage Rates Inc. 50%	(11) Alt. Sys. w/ 50% Increase in Wage rates	(12) Alt. Sys. w/ Nebraska Wage Rates Inc. 25%	(13) Alt. Sys. w/ 50% Increase trans. costs	(14) Alt. Sys. w/ 100% increase trans. costs
	dollars/cwt.													
(1) WA-OR	0.00	0.00	-0.23	-0.23	0.00	0.00	0.00	-0.06	0.00	0.00	0.00	-0.71	-1.69	-3.49
(2) N. CA	-2.97	-2.24	-2.24	-2.24	-2.24	-2.24	-2.24	-2.24	-2.24	-3.43	-3.19	-2.24	-4.09	-5.94
(3) S. CA	-3.63	-2.55	-2.55	-2.56	-2.56	-2.56	-2.56	-2.56	-2.56	-3.79	-3.64	-2.56	-4.31	-6.07
(4) AZ	-4.75	-6.61	-4.98	-6.60	-6.60	-6.60	-6.60	-6.60	-6.60	-7.45	-7.72	-6.60	-7.90	-9.20
(5) UT-NV	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	-1.30	0.00	0.00	0.00	0.00	0.00
(6) MT-ID-WY	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
(7) CO	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	-1.09	-0.94	0.00	0.00	0.00
(8) NM	-4.82	-6.86	-6.18	-6.86	-6.86	-6.86	-6.86	-6.86	-6.86	-7.67	-8.22	-6.86	-7.68	-8.51
(9) TX-OK PAN.	-2.19	-2.58	-2.57	-2.58	-2.58	-2.58	-2.58	-2.58	-2.58	-3.62	-3.47	-2.58	-2.68	-2.76
(10) W. TX	-2.69	-3.15	-2.92	-3.16	-3.16	-3.16	-3.16	-3.16	-3.16	-4.74	-5.00	-3.16	-3.47	-3.78
(11) S. TX	-4.00	-4.94	-5.02	-5.03	-4.93	-4.93	-4.88	-6.20	-6.20	-7.55	-7.38	-5.03	-5.25	-5.46
(12) SE. TX	-5.46	-6.50	-6.48	-6.49	-6.39	-6.39	-6.34	-7.66	-7.66	-7.89	-7.72	-6.49	-7.40	-8.30
(13) E. TX	-4.13	-4.35	-4.51	-4.35	-4.35	-4.35	-4.35	-4.35	-4.35	-5.42	-5.26	-4.35	-5.33	-6.32
(14) E. OK	-3.78	-3.25	-3.97	-3.97	-3.25	-3.25	-3.25	-3.39	-3.25	-4.54	-4.40	-3.25	-3.97	-4.68
(15) KS	-2.26	-2.14	-2.45	-2.45	-2.14	-2.14	-2.14	-2.28	-2.14	-3.37	-3.23	-2.14	-2.28	-2.39
(16) NE	-3.41	-4.41	-4.71	-4.71	-4.40	-4.40	-4.35	-4.54	-4.40	-6.13	-6.11	-1.83	-4.51	-4.64
(17) ND-SD	-0.58	-1.65	-1.95	-1.95	-1.64	-1.64	-1.59	-1.78	-1.64	-3.03	-3.09	-2.43	-1.56	-1.50
(18) MN-WI	-1.09	-0.89	-1.19	-1.19	-0.88	-0.88	-0.83	-1.02	-0.88	-2.12	-1.99	-0.80	-1.13	-1.41
(19) IA	-1.48	-1.11	-1.61	-1.41	-1.10	-1.10	-1.05	-1.24	-1.10	-2.36	-2.23	-1.05	-1.40	-1.73
(20) IL	-3.33	-4.33	-4.64	-4.64	-4.33	-4.33	-4.28	-4.48	-4.34	-4.55	-4.54	-4.34	-5.37	-6.38
(21) MO	-4.30	-4.30	-4.49	-4.61	-4.30	-4.30	-4.30	-4.44	-4.30	-5.51	-5.37	-4.30	-5.14	-5.99
(22) AR-LA	-6.70	-7.70	-7.78	-7.79	-7.69	-7.69	-7.64	-7.79	-7.69	-9.17	-9.16	-7.79	-8.91	-10.04
(23) FL	-9.99	-10.99	-11.30	-11.30	-10.99	-10.99	-10.94	-11.13	-10.99	-14.14	-14.13	-11.61	-12.67	-14.39
(24) MS-AL-GA	-4.26	-4.72	-4.45	-4.62	-4.71	-4.71	-4.71	-4.85	-5.45	-5.87	-5.72	-4.71	-5.94	-7.16
(25) NC-SC	-7.71	-8.71	-9.01	-9.01	-8.70	-8.70	-8.65	-8.84	-8.70	10.47	-10.46	-9.65	-10.85	-13.02
(26) KY-TN	-4.46	-5.46	-5.77	-5.77	-5.46	-5.46	-5.41	-5.60	-5.46	-6.03	-6.01	-6.33	-6.71	-7.99
(27) VA-WVA-MD-DE	-10.98	-11.98	-12.28	-12.28	-11.97	-11.97	-11.92	-12.11	-11.97	-15.40	-15.39	-13.10	-14.18	-16.41
(28) MI-IN-OH	-4.08	-3.46	-4.27	-3.77	-3.46	-3.46	-3.46	-3.60	-3.46	-4.76	-4.62	-3.46	-4.66	-5.85
(29) PA	-4.37	-4.40	-4.50	-4.54	-4.38	-4.38	-4.33	-4.52	-4.38	-5.59	-5.45	-4.33	-6.45	-8.56
(30) North East	-4.27	-4.64	-4.95	-4.95	-4.64	-4.64	-4.59	-4.78	-4.64	-5.17	-5.03	-5.83	-7.05	-9.49

Table 38. Eight next least cost opportunity shipping routes, by model, shipping-receiving region, and packaging/distribution system.

	Least Opportunity Cost Rank															
	1		2		3		4		5		6		7		8	
Model	Ship.-Rec. Region[a]	Pkg.-Dist. System[b]	Ship.-Rec. Region	Pkg.-Dist. System	Ship.-Rec. Region	Pkg.-Dist. System	Ship.-Rec. Region	Pkg.-Dist. System	Ship.-Rec. Region	Pkg.-Dist. System	Ship.-Rec. Region	Pkg.-Dist. System	Ship.-Rec. Region	Pkg.-Dist. System	Ship.-Rec. Region	Pkg.-Dist. System
1	18 to 29	BB (.05)	7 to 4	BB (.06)	15 to 29	BB (.06)	19 to 28	BB (.06)	11 to 22	HRI (.06)	16 to 3	HRI (.06)	8 to 3	HRI (.10)	9 to 14	BB (.11)
2	15 to 20	CV (.01)	16 to 29	CV (.03)	18 to 29	CV (.04)	15 to 22	CV (.05)	15 to 29	CV (.05)	7 to 4	CV (.06)	19 to 28	CV (.06)	1 to 1	HRI (.07)[c]
3	15 to 26	CV (.00)	7 to 3	CV (.01)	15 to 20	CV (.01)	7 to 28	BB (.02)	18 to 29	BB (.02)	15 to 15	BB (.03)	9 to 30	CV (.04)	9 to 23	BB (.05)[d]
4	1 to 1	CV (.00)	7 to 30	CV (.00)	9 to 26	CV (.01)	15 to 20	CV (.01)	7 to 28	CV (.03)	9 to 30	CV (.05)	15 to 25	CV (.05)	19 to 28	CV (.05)
5	1 to 1	CV (.00)	15 to 20	CV (.01)	16 to 29	CV (.04)	15 to 22	CV (.05)	7 to 4	CV (.06)	15 to 29	CV (.07)	16 to 28	CV (.08)	1 to 1	HRI (.08)[e]
6	1 to 1	CV (.00)	15. to 20	CV (.01)	16 to 29	CV (.04)	15 to 22	CV (.05)	18 to 29	CV (.05)	19 to 28	CV (.05)	7 to 4	CV (.06)	15 to 29	CV (.07)
7	1 to 1	TR (.00)	16 to 28	CV (.03)	16 to 29	CV (.04)	15 to 22	CV (.05)	17 to 28	CV (.05)	18 to 29	CV (.05)	7 to 4	CV (.06)	15 to 20	CV (.06)
8	1 to 1	CV (.00)	20 to 20	HRI (.01)	16 to 29	CV (.04)	16 to 22	HRI (.04)	18 to 29	CV (.05)	19 to 28	CV (.05)	7 to 4	CV (.06)	16 to 28	CV (.08)[f]
9	1 to 1	CV (.00)	20 to 20	HRI (.01)	16 to 29	CV (.04)	15 to 22	CV (.04)	18 to 29	CV (.05)	19 to 28	CV (.05)	7 to 4	CV (.06)	15 to 29	CV (.07)
10	8 to 8	CV (.00)	8 to 3	HRI (.03)	19 to 28	TR (.05)	18 to 29	TR (.06)	15 to 29	TR (.07)	11 to 11	CV (.10)	9 to 14	TR (.11)	9 to 25	TR (.13)[g]
11	17 to 17	TR (.01)	9 to 2	CV (.03)	7 to 4	TR (.05)	18 to 29	TR (.05)	19 to 28	TR (.05)	15 to 29	TR (.07)	10 to 10	CV (.08)	16 to 27	CV (.08)[h]
12	1 to 1	CV (.00)	16 to 29	CV (.01)	18 to 29	CV (.02)	19 to 30	CV (.03)	11 to 23	HRI (.04)	15 to 22	CV (.05)	18 to 28	CV (.05)	7 to 4	CV (.06)
13	1 to 1	CV (.00)	16 to 20	HRI (.03)	16 to 28	CV (.04)	16 to 21	HRI (.04)	16 to 29	CV (.05)	19 to 20	CV (.06)	15 to 22	CV (.08)	15 to 30	CV (.08)[i]
14	12 to 12	HRI (.00)	1 to 1	CV (.01)	16 to 28	CV (.06)	16 to 29	CV (.07)	19 to 20	CV (.08)	15 to 22	CV (.10)	18 to 29	CV (.10)	7 to 4	CV (.11)[j]

[a]Shipping-receiving region.

[b]Packaging-distribution system. BB = boxed beef, TR = tray-ready, CO = central overwrap, CV = central vacuum, HRI = hotel, restaurant, and institution.

[c]also ranked eighth was 21 to 21 HRI (.07).

[d]also ranked eighth were 18 to 28 BB (.05) and 9 to 27 CV (.05).

[e]also ranked eighth was 21 to 21 HRI (.08).

[f]also ranked eighth was 21 to 21 HRI (.08).

[g]also ranked eighth was 18 to 28 TR (.13).

[h]also ranked eighth were 17 to 2 CV (.08), 16 to 3 HRI (.08), and 17 to 2 HRI (.08).

[i]also ranked eighth was 18 to 29 CV (.08).

[j]also ranked eighth was 15 to 30 CV (.11).

29 (Pennsylvania) provided total costs decreased at least $0.03 per hundredweight. The data in Table 38 for Model 2 are summarized and ranked from data in Tables 13 and 14.

These least cost opportunity shipping routes provide insights into the "next" or potential packaging/distribution systems, by shipping/receiving region, which could enter the least cost or optimum solution if some cost component were to decrease by at least the specified amount. For example, least-cost opportunity coefficients in Model 6 reveal that central-vacuum-packaging systems have a "potential" competitive advantage over other systems if costs were to decrease by the amounts specified. Further, Model 10 least-cost opportunity coefficients suggest that tray-ready packaged beef would potentially have a competitive advantage over other packaging/distribution systems in the first five out of nine comparisons if packaging/distribution costs were to decrease. These least-cost opportunity coefficients are important for ranking or determining the next potential packaging/distribution system, by shipping/receiving region, which would occur provided the scenarios occur as specified in the various models and the overall objective is to minimize costs to the system.

Implications of Industry Technology Adoption Rate by Packaging/Distribution System

Industry technology adoption rate is often impacted by numerous factors or a combination of factors relating to costs, profits, output, health and safety considerations, competition, regulatory standards, product development, etc. Recall, this study focused primarily on the economics of alternative beef packaging/distribution systems compared to boxed beef as previously discussed.

Industry adoption of a case-ready beef packaging system is impacted not only by economic considerations but also by the consumer's reaction to changes in packaging technology. From the consumer perspective, acceptability of such changes in technology may be tempered by such accompanying changes as product costs, appearance, or product color associated with a specific packaging/distribution system, package size, and other attributes of the particular package. Given the above considerations, including reaction to change itself, it was assumed that considerable promotion and advertising would be required to entice consumers to make initial purchases of beef in new (alternative) packaging systems. Consequently, the industry/consumer case-ready adoption rate was broadly categorized into four time frames: (1) initial start-up, (2) short-run adoption, (3) intermediate-run adoption, and (4) long-run adoption.

Initial Start-up Adoption

Under the initial start-up scenario, total alternative packaging/distribution system costs were increased over base costs such that the average total alternative system retail costs were equivalent to boxed beef retail costs. Results from the VAL-ADD model revealed that costs would be minimized under such a scenario when 47 percent of the non-HRI domestic beef was merchandised as boxed beef and 53 percent of the remainder was merchandised as central-vacuum-packaged beef. It is significant to note that industry adoption of central-vacuum versus boxed-beef packaging on a regional basis was dependent upon the level of retail wage rates. Regions with relatively lower retail wage rates minimized total costs when beef was packaged and distributed as boxed beef. Conversely, regions with relatively higher retail wage rates minimized costs by purchasing beef which was packaged as central-vacuum beef at the packer level.

Adoption of HRI-packaged beef and boxed beef for export is not discussed in this section. The VAL-ADD model required that 30 percent of all domestic beef consumption be obtained from HRI sources in all scenarios modeled to coincide with 1988-89 consumption patterns. Further, all surplus beef was destined for export as boxed beef.

Short-run Adoption

The short-run time period in terms of packaging technology is not clear at this time. This study assumed that short-run adoption referred to that time period after the initial start-up promotion program to the intermediate-run adoption period. Short-run adoption assumes that packaging technology is given and that variable cost adjustments relating to labor costs at retail and promotional costs can be decreased from the initial start-up costs for all central packaging systems such that total system costs decline $3.00 per hundredweight (retail equivalent). Given the above scenario, the VAL-ADD model revealed that central-vacuum-packaged beef had the potential to account for more than 80 percent of the non-HRI domestic beef merchandised. Boxed beef was the second most important packaging/distribution system, accounting for 14 percent of the total, followed by tray-ready with 3 percent. Domestic boxed beef shipments, again, were destined only to those regions having the lowest retail labor rates. Almost all of the remaining beef that was marketed in the U.S. was packaged and distributed at the packer level as central-vacuum-packaged beef, since total system costs were minimized when these services were performed at the slaughter level where wage rates were substantially lower than at the retail level, Table 1.

Intermediate- and Long-run Adoption

Intermediate-run adoption of packaging technology was defined as that time period when packaging technology was given and the variable costs of labor and promotional activities were further decreased to the extent that total system costs, and initial start-up costs declined by $6.00 per hundredweight. Long-run adoption was defined as that time period, after intermediate-run adoption, when packaging technology could change, although specific packaging systems in this study were unchanged to accommodate comparisons to previously specified systems. The long-run adoption scenario further assumed that adjustments could be made in all costs including fixed facilities such that total system costs declined by $9.00 per hundredweight compared with initial start-up costs.

The VAL-ADD model revealed that intermediate-run and long-run adoption rates, as impacted by the above cost scenarios, would achieve similar results with respect to optimal packaging/distribution systems, optimal distribution routes by packaging distribution system, and intraregional and interregional opportunity shipping costs. These results imply that cost declines in the range of $6.00 to $9.00 per hundredweight over all packaging/distribution systems, would have a minimal impact on the optimal packaging distribution systems. When the intermediate- and long-run scenarios were imposed on the VAL-ADD model, central-vacuum-packaged beef accounted for 97 percent of the non-HRI domestic beef merchandised in both scenarios. This assumes that the beef color disadvantage associated with central-vacuum beef will be overcome in the long run. The remaining 3 percent consisted of tray-ready beef.

The above adoption rates for the intermediate- and long-run scenarios were impacted by the basic industry and system costs for 1988-89 and assumptions regarding the various scenarios imposed on the VAL-ADD model. Further assumptions regarding (1) potential increases in labor costs while other costs remained relatively unchanged, and (2) potentially relative lower start-up merchandising costs for some packaging/distribution systems, including tray-ready, central overwrap, and gas flush, compared with central-vacuum-packaged beef also impact long-run adoption. The VAL-ADD model showed that central-vacuum and tray-ready-packaged beef are highly competitive and that changes in cost items such as labor and merchandising costs tend to afford competitive advantage to one packaging/distribution system over the other system, depending upon the direction of cost changes. If costs such as labor and merchandising costs were to increase substantially more than other system cost items, the VAL-ADD model suggested that long run adoption would favor tray-ready over central vacuum. Conversely, relative decreases in major cost items such as labor and merchandising costs over all systems, with other costs remaining relatively stable, tends to provide a competitive advantage to central-vacuum-packaged beef over the tray-ready system.

Supplemental analyses generated through the VAL-ADD model also revealed that if initial start-up merchandising costs are substantially lower for one case-ready system over another system, the system with the lower initial merchandising cost could have a competitive advantage, depending upon the labor intensiveness of the system and the impact upon overall system costs. For example, if total system retail costs for tray-ready-packaged beef were $1.00 per hundredweight lower than central-vacuum-packaged beef as a result of lower initial merchandising costs, the VAL-ADD model suggested that the competitive advantage relative to adoption at retail would accrue to tray-ready over central vacuum. Adoption of packaging systems, by region, may be impacted by such factors as regional wage rates, consumer reaction to specific packaging systems, retail firm preference of packaging systems, and health and safety considerations.

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APPENDIX A: VAL-ADD Model

The model used in this study follows the basic transshipment cost minimization problem presented below:

$$\sum_{i=1}^{30}\sum_{j=1}^{31} C_{ij}X_{ij}$$

Subject to:

Supply of beef carcasses by packers/purveyors.

$$\sum_{i=1}^{30}\sum_{j=1}^{31}\sum_{k=1}^{7} X_{ijk} \leq S_i$$

Demand for retail beef by stores.

$$\sum_{i=1}^{30}\sum_{j=1}^{31} X_{ijk} = D_j$$

Where:

C_{ijk} = The total cost ($/hundredweight) of distributing beef from packer and/or purveyors in region (i) to retail firms in region (j) by system (k).

X_{ijk} = The amount of beef distributed from packers/purveyors in region (i) to retail store in region (j) through system (k).

S_i = Supply of carcasses to packer/purveyors in region (i).

D_j = Demand for retail beef by stores in region (j).

(i) = 1,...,30; packer/processor carcass supply regions.

(j) = 1,...,31; retail demand regions, with Region 31 as importers from the United States.

(k) = 1,...,7; fabrication and distribution systems.

APPENDIX B: Regional Beef Demand

Per capita beef demand was assumed to be influenced by disposable income, retail price and time. Given this, the following equation was used to estimate average U.S. per capita beef demand:

$$Y=\beta_0+\beta_1X+\beta_2X_2+\beta_3X_3$$

Where,

Y = per capita beef demand.

X_1 = per capita disposable income.

X_2 = retail beef price.

X_3 = Year, where 1978=1 and 1987=10.

Per-capita disposable income data were collected by state and county from the U.S. Department of Commerce, Bureau of the Census and Bureau of Economic Analysis, from 1978 to 1987. These data were deflated by the consumer price index and assembled by each region.

The 1988 average U.S. retail beef price of $2.55 per pound was obtained from the U.S. Department of Agriculture, Livestock and Poultry Situation and Outlook Report and combined with regional price differentials (Dietrich[9]) to estimate regional average retail prices. The resulting function for estimating 1988 regional per-capita beef demand was:

$$Y = 82.45413 + 0.00472(X_1) - 0.15693(X_2) - 2.97198(X_3)$$

$F = 55.95$ $R^2 = .9655$

Variable	Parameter Estimates	T-Value	Probability >/t/
β_0	82.454137	9.211	.001
X_1	0.004717	9.170	.001
X_2	-0.156925	-7.885	.001
X_3	-0.971983	-10.986	.001

Regional per capita beef consumption was estimated by inserting regional per capita disposable income and regional retail beef price into the above equation. Regional per capita beef consumption was then multiplied by regional population to estimate regional beef demand.

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